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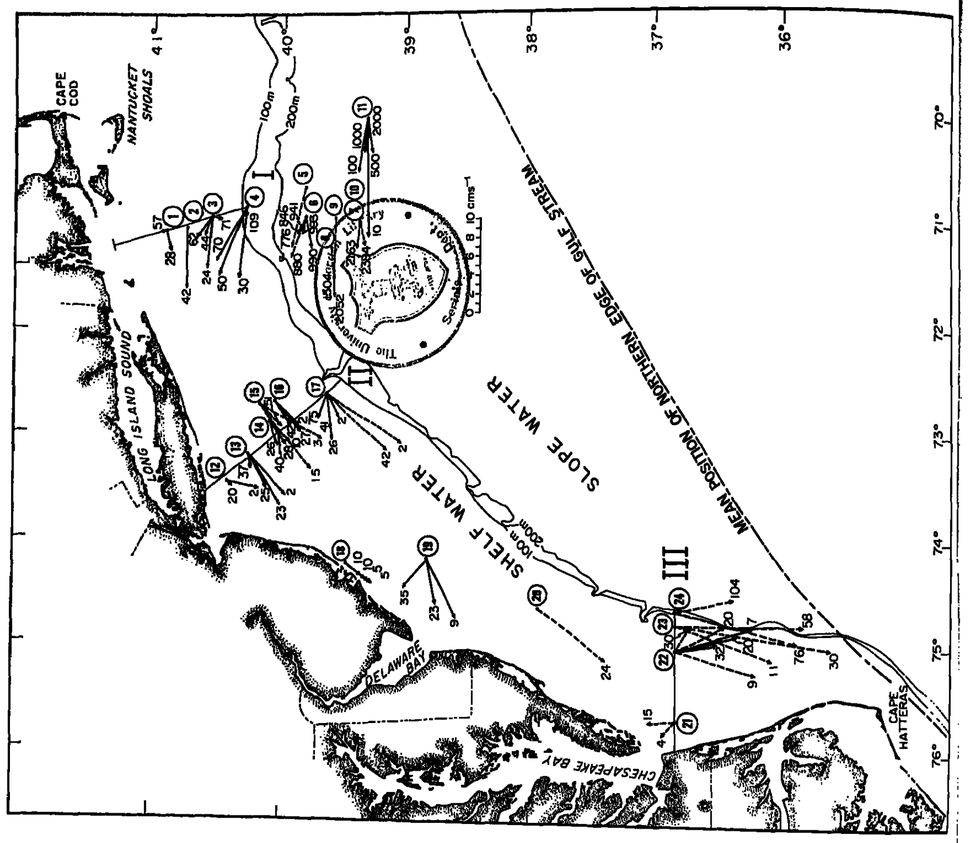

EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL. 62, NO. 5, PAGES 41-48 FEBRUARY 3, 1981

International Ocean Technology Conference

A call for papers has been issued for Oceans '81, an international ocean technology conference, scheduled for September 16–18 in Boston, Massachusetts.

Abstracts, due March 1, should be no longer than 400 words and should be structured in four sections: title and author; problems addressed, including background; procedure applied; and results and conclusions. Abstracts must be in English and should accompany a brief biographical sketch of the author(s). Papers may be presented in a lecture or in a poster session.

Authors of papers selected for presentation will be notified by mail by April 1. Camera-ready papers are due June 1.

Abstracts and biographical sketches should be sent to Oceans '81, Technical Program Committee, P.O. Box 132, Portsmouth, Rhode Island 02871. Additional information can be obtained from the above address or by calling James Barger, Committee Chairman, at (617) 491-1850.

The conference is sponsored by AGU, the IEEE Council of Oceanic Engineers, the Boston section of IEEE, the Marine Technology Society (MTS), the New England section of MTS, and the Southern New England section of MTS. EOS

Migration to the Shore

The Center for Coastal Studies at the Scripps Institution of Oceanography will sponsor an international symposium entitled 'Quaternary Land-Sea Migration Bridges and Human Occupation of Submerged Coastlines' on October 26–31.

Marine archaeology and the migration of early man in the coastal regions of the world is one subject area being studied at the new center.

For additional information about the center or about the symposium, telephone Douglas L. Inman, center director, 714-452-4334, or Patricia M. Masters, coordinator of the marine archaeology program, 714-452-2995. EOS

European Union of Geosciences

The first meeting of the European Union of Geosciences is scheduled for April 13–16 in Strasbourg, France. In addition to the regular sessions, several symposia will be held.

Symposia topics include basin evolution from heat flow to oil; episodic versus continuous geodynamics processes; continental development and structure; early development of the earth; European seismicity and earthquake prediction; paleoclimates; ophiolites and greenstone belts; and magma generation and segregation.

Travel grants will be awarded for submission of high-quality abstracts.

For information on registration, abstract submission, housing, and awards, write to European Union of Geosciences, Organizing Committee, Institut de Physique du Globe de Paris, Universite Paris VI, 4 Place Jussieu, 75230 Paris Cedex 05, France. EOS

EOS
TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

The Weekly Newspaper of Geophysics

Eos invites contribution of reviews, short articles, meeting reports, news notes on recent research, and letters to the editor. Material must be readable, contain little or no mathematics, be of broad interest to scientists in the various disciplinary sections of the Union, and be timely.

Eos also welcomes contributions dealing with the interfaces of geophysics with society. This newspaper is an effective way to address those involved in the study of the earth and its environment in space.

Send double-spaced manuscripts (four copies) to *Eos*, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

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AGU Congressional Science Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science, be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $25,000 plus travel allowances.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write Member Programs Division, Congressional Fellowship Program, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Deadline: March 31, 1981.

Cover. An Apollo view of the moon's 11-km-diameter crater, Goddard A, and associated swirl patterns. The swirl patterns are unlike typical crater rays, which become brighter at larger phase angles. One proposal by P. H. Schultz and L. J. Srnka suggests that they represent imprints of the fine-scale structure of the inner coma of a comet (*Nature*, 284, 1980). The collision of these swirl pattern regions locally heated, scoured, and altered the upper regolith, thereby producing the unusual photometric properties. The correlation of such swirl patterns with strong magnetic anomalies might be explained by the compression of magnetic field lines that takes place within the coma during collision, and which is recorded by altered regolith materials. (Photo courtesy of P. H. Schultz, Lunar and Planetary Laboratory, Houston, Texas.)

Editorial

AGU Annual Meetings

The purpose of this editorial is to inform AGU members about the procedures for scheduling the annual meetings, to explain the role of the section program chairmen, and to emphasize the importance of timely submission of abstracts.

The dates and locations for the annual meetings are set by the AGU Council, based on recommendations from the Meetings Committee. In making these recommendations the Meetings Committee considers the suggestions of AGU members and reviews possible sites on the basis of facilities, costs, convenience to transportation, probable weather conditions, number of local AGU members, and general attractiveness of the host city. The choice of meeting dates as well as the location is heavily influenced by hotel costs since the rates which can be negotiated with the hotels depend on the expected demand for hotel rooms. Thus, this year, the Spring Meeting is scheduled for the week that includes Memorial Day, when business travel and hotel demand is reduced. In the past it has sometimes been necessary to schedule the meeting to straddle a weekend in order to obtain lower hotel rates. The inconvenience of meeting on weekends and holidays is recognized, but it is felt that the cost savings achieved in this way are essential. The point to be emphasized is that the selections are not made lightly, and the Meeting Committee, the AGU staff, and the AGU Council make a thorough evaluation of potential sites and dates before making a decision.

Once the dates for an AGU meeting have been decided, the overall scheduling, which includes setting the date for the call for papers, the abstract deadline, the program chairmen's meeting, and the mailing of the program in *Eos*, is derived by considering the time required for completing these various steps. Recognizing the desirability of having up-to-date abstracts, the abstract deadline is set as late as possible. However, this tactic necessarily limits the time available for all subsequent steps in arranging the program.

These factors conspire to place a severe burden on the section program chairmen in planning the programs. These chairmen are responsible for organizing special sessions, grouping the contributed abstracts into coherent sessions, selecting session chairmen, and scheduling the time and room assignment of each session. A section program chairman has approximately 2 weeks between his receipt of on-time abstracts and the program chairmen's meeting. At the program chairmen's meeting, which typically takes 2 days, the entire program is completed, meeting rooms are assigned, and efforts are made to minimize conflicts between various sessions. At this time, abstracts that may have been misdirected are transferred to the proper section program chairmen. Throughout the 2-week period between abstract deadline and the chairmen's meeting, the continuous arrival of late abstracts can disrupt the work of these chairmen. In some cases a chairman has arrived at the program meeting with his program completely organized but is confronted with an additional 20 to 30 late abstracts. These abstracts cover a multitude of subjects and cannot be grouped into a single session. Adding them to existing sessions will extend those sessions unduly. The net result is that the program chairman is forced to reorganize his entire program on short notice during a time when he is busy with the other affairs of the program meeting.

The problem of the late receipt of abstracts is a serious one. In 1978, fully 60% of the abstracts arrived after the meeting deadline. To help alleviate the situation a $25.00 penalty was assigned to abstracts that arrived late. At the 1980 Fall Meeting, only 17% of the abstracts were received late, but this figure is still inconveniently large. While it is recognized that the deteriorating U.S. Postal Service is partly responsible, assigning blame to a federal agency does not reduce the difficulty of processing late abstracts. I urge you to make every effort to mail abstracts early enough to ensure their timely arrival or send them by more expensive but reliable services such as Federal Express.

The AGU annual meetings have been growing steadily in both attendance and number of papers presented, and the meeting facilities available at most cities are now barely adequate. Furthermore, the large numbers of papers make simultaneous sessions necessary for most sections. To make the meetings more manageable and productive, there will in the future be increased emphasis on poster sessions and a rigid enforcement of the limit of one first-author contributed paper per member. In addition, more topical conferences and symposia will probably be held to supplement the annual meetings.

The vitality of the annual meetings is a major factor in the health of geophysical research. The Meetings Committee, the program chairmen, and the AGU staff are receptive to suggestions from the membership that can lead to more effective meetings. With the growth in attendance and in contributed papers it will be necessary for the meeting structure to evolve, and your help in suggesting changes will be appreciated.

Martin Walt
Meetings Chairman

News

Fiscal 1982 Budget Highlights R&D

Geophysical research and development programs show growth beyond inflation in the $739.3 billion budget for fiscal 1982 that Jimmy Carter sent to Congress 5 days before completing his term. Included in the budget are provisions for increased support for the Ocean Margin Drilling Program and funds for an Interagency Geological Applications Program, funds for an agriculture and resource surveys program that relies on remote sensing, and funds for the Venus Orbiting Imaging Radar mission.

Ronald Reagan is expected to make changes in the budget as early as late February, although in mid January the heads of the scientific agencies could not characterize possible changes. Some Washingtonians say sharp cuts are inevitable, with basic research a prime candidate. Others, however, contend that the Reagan administration's push for productivity and innovation could prevent severe carving. *Eos* will track the FY 1982 budget changes through congressional approval.

R&D Shows Real Growth

Obligations, or commitments of monies (not actual outlays) for conduct of all federally funded R&D total $41.7 billion for fiscal 1982, an increase of $6.5 billion or about 18.5% over 1981 obligations (Table 1). With the inflation rate at about 10%, the proposed budget shows real growth for R&D of about 8.5%. Within the R&D budget, obligations for basic research show a 14.4% increase (Table 2). Biggest increase for basic research among the agencies fell to NASA. Funds for conduct of R&D at universities and colleges barely scraped above inflation, with an 11.3% increase (Table 3).

The National Aeronautics and Space Administration (NASA) total budget fared well with an increase of 21% over 1981. Among federal agencies, this increase—to a $6.7 billion purse—is second only to that for the Defense Department's proposed total budget.

NASA R&D obligations show a 21.5% increase over those of 1981. Over $2.2 billion, or about half of NASA's R&D request, is slated for the space shuttle. The shuttle is the 'centerpiece of [NASA's] civil and military space efforts throughout the 1980s,' according to Robert Frosch, former NASA Administrator. The first orbital flight test is scheduled for March, with three more test launches in 1981 and 1982. The first operational flight will follow in late 1982.

Another highlight of the NASA budget is $40 million for the initiation of the Venus Orbiting Imaging Radar (VOIR) mission (*Eos*, December 2, p. 1202). One VOIR spacecraft, scheduled to be launched from the shuttle in 1986, will probe Venus' dense cloud cover to discover more about the planet's geophysics and atmosphere.

Request for development of the Gamma Ray Observatory (GRO) nearly triples over 1981's $17.6 million. GRO will be launched in 1986 to study objects in the universe in the gamma ray spectral region. Fabrication work will also continue on the International Solar Polar mission; the 1982 budget request of $58 million is a 46% increase over the previous year.

TABLE 1. Federal R&D Obligations by Agency (Millions of Dollars)

Agency	FY 1980	FY 1981 est.	FY 1982 est.	Change 1981–82
DOD-Military	13,943	16,226	20,033	+ 23.5%
NASA	5,084	5,422	6,589	+ 21.5
DOE	4,737	5,167	5,642	+ 9.2
HHS	3,790	3,984	4,285	+ 8.1
NSF	868	1,015	1,157	+ 14.1
USDA	687	775	871	+ 12.3
Interior	438	485	496	+ 8.7
DOT	374	413	474	+ 14.8
Commerce	341	365	411	+ 12.8
EPA	348	364	345	– 5.2
Labor	215	153	330	+ 116.0
All Others	839	897	1,102	+ 22.8
Total	31,682	35,226	41,734	+ 18.5

Source: Office of Management and Budget

TABLE 2. Federal Basic Research Obligations by Agency (Millions of Dollars)

Agency	FY 1980	FY 1981 est.	FY 1982 est.	Change 1981–82
HHS	1,758	1,887	2,053	+ 8.8%
NIH	(1,639)	(1,759)	(1,909)	(+ 8.5)
NSF	812	923	1,057*	+ 14.4
DOE	523	591	710	+ 20.1
DOD-Military	539	605	704	+ 16.4
NASA	559	555	681	+ 22.8
USDA	275	322	367	+ 14.1
All Others	215	239	289	+ 21.3
Total	4,682	5,121	5,861	+ 14.4

*An additional $75 million in new funding is included under R&D facilities for NSF for modern scientific apparatus and facilities to support basic research at universities.

Source: Office of Management and Budget

(News cont. on page 50.)

(News cont. from page 49)

TABLE 3. Federal R&D Obligations to Universities and Colleges by Agency
(Millions of Dollars)

Agency	FY 1980	FY 1981 est.	FY 1982 est.	Change 1981–82
HHS	2,076	2,185	2,354	+ 7.8%
NIH	(1,897)	(2,011)	(2,159)	(+ 7.4)
NSF	666	761	868	+ 14.1
DOD-Military	451	528	639	+ 21.0
DOE	293	312	351	+ 12.6
USDA	221	241	283	+ 17.4
NASA	171	188	204	+ 8.5
All Others	312	326	353	+ 8.1
Total	4,190	4,541	5,053	+ 11.3

Source: Office of Management and Budget

Budget obligation for the Galileo mission to Jupiter swelled 71% to $108 million. Fabrication work will continue in FY 82 in preparation for separate launches, planned for 1985, of the mission's two major components. The halogen occultation experiment budget was raised 66% to $7.5 million.

Upper atmosphere research will be expanded in 1982 to start ground and space system studies and instrument design and testing for a future satellite mission to study the interactions among the chemistry, radiation, and dynamics of the upper atmosphere; $20 million has been budgeted for these experiments.

NSF: $75M To Improve Labs

The National Science Foundation (NSF) obligations for research and development in fiscal 1982 were boosted 14% to $1.16 billion. The big winner is a new program to upgrade and modernize university research instrumentation; NSF allocated $75 million to the program. Up to 120 awards, one per institution, will be made under the $75 million program to upgrade instrumentation and facilities. This program aims to increase the productivity and efficiency of research groups. Another goal is to improve the return on investment of federal research support funds.

Cooperative industry-university research projects also get a large boost in Carter's budget proposal. NSF has obligated $26.8 million, nearly double the 1981 level.

NSF-sponsored basic research will get $1.06 billion in 1982, 15% above 1981's funding level. Highest increases in basic research are allocated to the mathematical and physical sciences, to engineering, and to the social and economic sciences.

Funds to initiate construction of a 25-m, millimeter wave telescope on Mauna Kea, Hawaii, are included in the NSF purse. Complete design and initial fabrication, scheduled for fiscal 1982, will require $9.8 million. Approximately the same level of funding is expected for the following two fiscal years; installation of the telescope is scheduled for 1984.

Obligations for ocean drilling programs grow by 36.4% over 1981's obligation of $22 million; NSF has requested $30 million. The Deep Sea Drilling Project (DSDP) and the International Phase of Ocean Drilling (IPOD) together garner $14 million, down $3 million. The Ocean Margin Drilling Program (OMDP) is budgeted for an additional $11 million over 1981, bringing NSF's share in the program to $16 million. An identical amount will be allocated by U.S. petroleum companies. Planned for fiscal 1982 is the initial implementations phase, including detailed design, science planning, and long-lead-time procurement.

The Astronomical, Atmospheric, Earth, and Ocean Sciences Directorate shows real growth of 3.5%, with a budget obligation of $268 million.

In terms of real growth, the U.S. Antarctic Program will shrink by about 2%; the overall 8% increase does not cover the calculated rate of inflation. NSF has requested $70.1 million for the program. Cutbacks at Siple Station (*Eos*, November 11, p. 906) were caused by increased fuel costs.

Support of applied research programs shows no real growth above inflation in fiscal 1982. Funding increased 10.9% to $90.2 million.

NOAA Expands Acid Rain Research

The National Oceanic and Atmospheric Administration (NOAA) has been allocated $1.05 billion of the federal bankroll, an increase of 23.7% over 1981. NOAA fared better than the Department of Commerce as a whole. Ocean and atmospheric services is slated for 42.7%, or $449.1 million, of NOAA's budget; the satellite programs' share is $274.6 million (26.1%), followed by fisheries ($151.6 million or 14.4%), research and development ($129.5 million or 12.3%), and coastal zone management ($46 million or 4.4%).

Support will be expanded for acid rain research and on improved methods of detecting, tracking, and forecasting weather systems and violent storms.

Much of NOAA's increase is reflected in the transference of LANDSAT to the environmental satellite services division; NOAA is now the lead agency for all civilian satellite operations. The 1982 budget request includes $122.4 million for first-year costs of the interim LANDSAT system. Total budget increase for the environmental satellite service is 181% over 1981.

Specialized environmental services showed a 4.1% increase to $46.8 million, but within it the air pollution and fire weather services jumped 49% to $5.7 million. This increase is the result of expanded research, planned to investigate acid rain pollution. This research received an additional $1.9 million over the 1981 funding level.

Other divisions of NOAA did not even keep up with inflation in the proposed budget. Basic environmental services increased 5.9% to $166.4 million. Public forecast and warning services increased 7.4% to $101.3 million, all reflected in one program. Public weather services increased $7 million to $59.8 million.

NOAA's budget provides for the continued operation of the two weather satellite systems and the development of an ocean satellite system. No funding is proposed, however, for coastal energy impact formula grants or for coastal environment grant and credit assistance in fiscal 1982.

One new responsibility NOAA takes on in fiscal 1982 is to license and regulate ocean thermal energy conversion (OTEC) and deep seabed mining.

USGS Budget Sliced by 9%

The fiscal 1982 budget request pares the U.S. Geological Survey (USGS) funds by nearly 9%, to $575.8 million. Research priorities within the survey include investigating the causes and effects of geologic and environmental hazards such as earthquakes, volcanos, ground failure, acid rain, and toxic wastes.

Increases in the office of geologic and mineral resource surveys and mapping will provide for growth of the earthquake program. Development of a system to monitor continuous strain in southern California is included in this category. In addition the USGS will initiate two programs: one will coordinate a research program in landslide hazards warning and mitigation, and the other will research deep continental crust.

Under the water resources investigations office, the USGS will initiate a program to research the effects of acid rain. The NOAA and USGS programs in acid rain pollution are an attempt to understand and quantify the phenomena. The water resources office will also initiate a program on the prevention and mitigation of groundwater contamination. Despite these program initiations, the office's budget doesn't beat inflation: funding increases only 5.6% to $125.7 million.

The Water and Power Resources Service, another part of the Department of the Interior, shows an increase of 13.5% to $913.5 million in fiscal 1982 obligations.

Budget Includes Interagency Programs

Three interagency programs budgeted for fiscal 1982 directly involve geophysics. A new program, the Geological Applications Program (GAP), with budget obligations totaling $19 million for 1982, will coordinate research activities among the USGS and NASA. Measurement techniques based on remote sensing developed by NASA will be tested in mineral appraisal projects conducted by the survey. NASA and USGS geologists will jointly develop new models and analyze remote sensing and ground truth data to provide an overall evaluation of the utility of space techniques for mineral resource assessment. NASA will contribute $10 million.

The second interagency program, dubbed AgRISTARS (Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing), is a continuing program designed to assess the value of space remote sensing data for early warning of crop conditions and for improving worldwide agricultural production forecasts. Participating in the program are the Agriculture, Commerce, and Interior departments; NASA; and the Agency for International Development. Obligations total $54 million.

The third program, the National Oceanic Satellite System (NOSS), will continue as a joint effort of NASA and the departments of Defense and Commerce. This satellite system will provide global ocean data for use in marine weather forecasting and climate studies, marine transportation, and defense applications. Obligations in fiscal 1982 are slated at $95 million.—*BTS*

Data Systems Users Working Group

A Data Systems Users Working Group (DSUWG) has been formed, at the request of NASA's Office of Space Science (OSS), by members of the space science community concerned with improving the yield, significance, and pace of scientific output from the massive, and growing, data base generated by spacecraft observations. The first meeting of the DSUWG was convened at Marshall Space Flight Center (MSFC) on September 11 and 12, 1980, by cochairmen James L. Green (MSFC) and Eugene W. Greenstadt (TRW). Most of the attendees of the first meeting were investigators long occupied with handling large data sets or coordinating measurements of separate but related space plasma variables. This particularly included members of the Atmosphere Explorer (AE) team.

The meeting was organized around a series of talks that included descriptions of past and future data networks at both the institutional and national level. Representatives from MSFC described the data-based management system of the NEEDS (NASA End-to-End Data Systems) program, and representatives from Goddard Space Flight Center outlined the present state of standardization of computer network protocol. Discussion focused on the general state of past space science data bases, on the likely forms and problems of future data bases, and on the means of applying state-of-the-art manipulation techniques to expedite reduction and analysis of spacecraft data. Attention was directed particularly to the necessity of facilitating data communications and exchange between investigators and remote data sources via compatible computer networks comparable to those currently in routine use by banks, airplanes, and commodity traders.

The working group conferred on a statement of concern and a set of broad recommendations to be forwarded to NASA/OSS in order to encourage early adoption by that agency of measures designed to modernize and strengthen the nation's efforts at turning the accumulated and planned observational records into meaningful scientific conclusions. The DSUWG then organized itself into four subgroups to examine in detail the elements and implementation of an advanced data processing and distribution system. The subgroups and their chairmen are:

Data Base Standards	C. P. Sonett (Univ. of Arizona)
Networking and Communications Standardization	R. Gold (Applied Physics Lab, Johns Hopkins Univ.)
Hardware/Software	J. Doupnik (Utah State Univ.)
Policy Management	R. Heelis (Univ. of Texas, Dallas)

Space science investigators interested in contributing to the deliberations of the DSUWG should contact the chairman of the subgroup closest to their interests or either of the cochairmen of the working group.

The recommendations sent to NASA by the working group follow.

Recommendations

The DSUWG recognizes that correlative studies are now, more than ever, impeded by the inability of different institutions to efficiently manage and transfer data from one location to another in a timely fashion. The large volume of data obtained in the 1970's by each investigation should have required early scientific involvement and data-based management, which, except for the AE project, was generally not undertaken. In an effort to prevent this problem in the future, the DSUWG therefore recommends that NASA

- establish and reflect, through its internal organization, an explicit policy that scientific data management is a major concern of the agency;
- dedicate the requisite resources for planning and sustaining the flow of data through all phases of the data chain, from conception of a mission to conclusion of its data analysis;
- authorize the involvement of scientific investigators in all stages of the data chain, including system design, implementation, and utilization, and sanction the flexibility to modify the system according to data processing requirements;
- support and direct the application of advanced technology to the creation of facilities for sharing the processing, transmittal, storage, retrieval, and analysis of data in a commonly accessible and timely manner, both within and across mission and institutional boundaries.

The DSUWG also urges further study within the working group and NASA to explore and to help define details of standardization, protocol, communication, and operations necessary in order to implement the recommendations at the fastest practical pace. Worldwide standards of computer interchange are being devised; NASA should ensure that these standards are followed when confirmed and that interim systems be compatible as far as possible.

It is time to manage better the large quantities of existing and future space science data and provide the capability for easy access. It is foreseen that if these recommendations are properly implemented, enormous benefit is to be derived within the space science community.

This item was prepared and submitted by E. W. Greenstadt of the Space Sciences Department, TRW Defense and Space Systems Group.

Johns Hopkins Site of Space Institute

The Space Telescope Science Institute (STSI) will be located on the Homewood Campus of the Johns Hopkins University, Baltimore, Maryland. The Institute will perform critical mission science activity for the forthcoming space telescope mission. The 13.1-m spacecraft is to be placed into a 600-k-high orbit by the space shuttle, and it will perform scientific investigations for at least 15 years.

The Association of Universities for Research in Astronomy (AURA), a consortium of 14 universities, has been selected for final negotiation of a contract to establish, operate, and maintain STSI for the space telescope scheduled for launch in early 1985 on the space shuttle. The contractor's estimated cost for the initial 5-year contract is approximately $24 million. Additional funding will be required in support of a guest observer and archival research program, as it develops. The contract will contain options for three additional 5-year extensions.

The Institute will host American and foreign astronomers, who will come to the facility to use the space telescope much as they would use a ground-based observatory. The telescope's science data will be sent via a tracking and data relay satellite and the NASA communications network to the Goddard Space Flight Center, Greenbelt, Md., and then on to the Institute for use by the staff and guest scientists. Investigators will be able to ask controllers at Goddard to point the spacecraft at any desired field of view.

The Institute will establish space telescope science observation schedules, fund United States user participation, and provide direct technical support to observers before, during, and after their observations. It will also support research necessary for efficient use of the telescope, evaluate its scientific performance and advise NASA on instrument status, and process, archive, and publicize the telescope's findings.

The Institute will staff and operate the Space Telescope Support Center at Goddard. This is essentially the section of the Operations Control Center that melds observational requirements with practical spacecraft flight and control considerations.

Above the obscuring atmosphere, the space telescope's 2.4-m mirror will be able to observe 350 times the volume of space now visible from ground-based observatories. The combination of high resolution, increased sensitivity, and relatively large aperture should facilitate observation of objects 50 times fainter than can be seen from Earth. The facility can also be used for measurements of the ultraviolet region of the spectrum, which is mostly absorbed by Earth's atmosphere.—*PMB*

Cost Overruns Will Affect Galileo Mission

Recent news of the cost overruns in the development of the shuttle's upper stages that will affect launching of the proposed Galileo mission prompted the following statement from Robert A. Frosch, on the eve of his resignation from the post of NASA Administrator:

> You know that we have been carrying out a concentrated study of Shuttle upper stages for 2½ months now. This study was initiated in early November when we became concerned with the continued rapid escalation of estimated costs for the three-stage IUS (inertial upper stage). We have decided on the best course of action for the future, and I want to outline for you how I believe the nation should proceed.
>
> To outline the situation we are in now, there is a very low probability that we can prepare a three-stage IUS in time for Galileo orbiter and probe launches to Jupiter in 1984, as previously scheduled. Therefore, the budget that the President is sending to Congress provides funding for that mission in 1985. The three-stage IUS, if it could be developed by 1985 along the lines we have been following, could not accomplish the Galileo mission because of the higher energy requirements in that year.
>
> While it would be possible with a different IUS vehicle, not now under development, to launch the Galileo orbiter, the trajectory would take about 5 years from the 1985 launch to reach Jupiter. The probe would then be launched in 1986 by the same vehicle, but this would mark a great departure from our planetary program plans and would necessitate an unacceptably long gap in the scientific data that we achieve from these missions. The cost of both the planetary programs and the IUS would rise sharply with such an option.
>
> Now, as you know, we have also been working with the industry to look at the possibility of incorporating the Centaur stage into the Shuttle, an option that has been extensively studied and has frequently been proposed as an alternative to the three-stage IUS. I have concluded that within the 1981 and 1982 resources that the budget would provide we could begin modifications of the Centaur, provisions for integrating it with the Shuttle, and the relatively minor changes to launch facilities at the Cape (Kennedy Space Center, Fla.) so as to have that very powerful combination available for first launches in 1985. No other alternative upper stage is available on a reasonable schedule or with comparable costs. The Shuttle/Centaur would satisfy our planetary mission needs and would offer, both to commercial customers and to national security interests, a highly capable launch vehicle with growth potential.
>
> Therefore, NASA will expand discussions with the Air Force on the best means for providing upper stages to meet the needs of the nation in the second half of this decade and work with them to continue with development of the two-stage IUS, which both we and the Air Force are counting on for a number of critical missions. We will also make preparations with the General Dynamics Corp. (St. Louis, Mo.) to enable us to enter into a contract this spring for integration of the Centaur vehicle in the Shuttle for the 1985 Galileo and ISPM (International Solar Polar Mission) launches.
>
> Of course, significant changes of this magnitude in our plans will be subject to confirmation as the Administration changes. Pending review of NASA's recommendations by the new Administration and the Congress, NASA will work with the Air Force to permit orderly implementation of the Space Transportation System and our respective programs. —*PMB*

Einstein Observatory Resumes Operation

The orbiting Einstein Observatory has returned to full-time scientific operation after an onboard gyro that failed last August inexplicably came back to life, according to controllers at the Goddard Space Flight Center, Greenbelt, Md. First indications of maneuvering problems in the X ray observing satellite were noted last August, limiting the observatory's scientific investigations. During the following 6 weeks, ground controllers modified radio command instructions to the spacecraft, allowing them to bypass the troubled gyro and continue operations with the two remaining gyros. Since mid-October, controllers had attempted repeatedly to reactivate the faulty gyro by sending literally thousands of radio commands to the oiling subsystem, with no effect.

For reasons not yet fully understood, the inactive gyro began to function normally on December 6, and the spacecraft was able to resume normal operations. The satellite, known officially as the High Energy Astronomy Observatory (HEAO-2), was launched November 13, 1978. It was nicknamed Einstein, by the scientists involved in the mission, in honor of famed scientist-mathematician Albert Einstein and because of the proximity of its launch date to the 100th anniversary of Einstein's birth.

Designed for an operational life of 1 year, the observatory has operated for more than 2 years and is expected to continue for several months before its propellant supply is exhausted. In its more than 2 years of operation, the satellite has returned thousands of X ray pictures, which will provide scientists a better understanding of X ray activity in space and new clues to the origins of galaxies.—*PMB*

Geophysicists

Philip S. Justus has joined the Nuclear Regulatory Commission as a staff geologist in the Geosciences Branch, Division of Engineering, Office of Nuclear Reactor Regulation, which is based in Bethesda, Maryland.

Della Laura has been appointed chief of the U.S. Geological Survey's Office of International Hydrology. She had been the assistant chief of that office since July 1979.

Barney P. Popkin joined Dames and Moore in Houston as senior hydrologist in January. He was formerly on the staff of the University of Arizona's Environmental Research Laboratory.

Frank Press, director of the Office of Science and Technology Policy under President Carter, has been selected as the 19th president of the National Academy of Sciences. His 6-year term begins July 1. Press was president of AGU 1974–76, is a Fellow of AGU, and was the 1979 recipient of the William Bowie Medal.

Geophysical Events

This item comprises selected portions of *SEAN Bulletin*, 5(12), Dec. 31, 1980, a publication of the Smithsonian Institution.

Volcanic Activity

Mount St. Helens Volcano, Cascade Range, Southern Washington, USA (46.20°N, 122.18°W). All times are local (GMT – 8 h). Renewed dome growth took place at Mt. St. Helens in late December, without the large explosions that immediately preceded previous dome-building episodes in June, August, and October.

Activity was limited to minor seismicity and weak vapor emission for about a month after the October 16–18 explosions and dome extrusion. Frequent periods of very low level harmonic tremor, lasting a few minutes to several hours, began to appear on seismic records November 19. Bursts of higher-level tremor, similar to explosion events seen earlier at Mt. St. Helens, could often be correlated with ejections of vapor columns that sometimes contained ash. A few discrete shallow earthquakes were recorded but remained infrequent until late December.

A series of vapor plumes marked the volcano's behavior throughout much of December. A few minutes of stronger tremor accompanied emission of a vapor plume that rose to 3-km altitude December 7, and one of several bursts of higher-amplitude tremor on December 9 occurred as a plume was ejected to 2.7-km altitude at 1325. A new thin deposit of ash was noted on the upper south flank early December 12. Emission of this ash was not observed, but a burst of increased tremor had begun at 0417, lasting about 30 min. On December 13 at 2017, a plume reached 5.5-km altitude as higher-level tremor was recorded. Inspection of the dome December 15 revealed a new small crater in its southern edge. Adjacent to the new crater, a roughly triangular section of the dome had been removed, extending about 15 m along its outer edge and 30 m toward the center of the dome. Plumes associated with increased tremor rose to 3.3-km altitude December 16 at 0800 and December 17 at 1520. A plume reaching 6-km altitude was briefly visible through clouds on December 21 at 1409, accompanied by a short burst of tremor. Two days later, at 1258, seismic activity and vapor emission increased simultaneously. Gas and a little tephra rose to almost 3 km, but activity continued for only a few minutes. New crater floor cracks were apparent after this event.

Deformation measurements December 6 and 7 showed a halt or possibly a reversal of the outward movement of the northern crater rampart that had resumed in November. Measurements December 18 revealed little or no change. However, observations on the 23rd showed renewed northward displacement of the northern crater rampart. Fissures in the crater floor appeared to be widening as well as extending radially from the inner crater.

On December 25 the number of discrete shallow earthquakes began to increase. Seismicity peaked before noon December 27, averaging five events per hour and occasionally reaching eight per hour during the next 30 hours. Geophysicists at the University of Washington located about two dozen of these events. All were centered at 2-km depth or less and were within 1 km NW of the October dome. No migration of events was evident.

Aerial observations December 26 were hampered by poor visibility, but there were no apparent changes in the crater. Bad weather prevented additional observations of the crater until December 28 at 0900 when U.S. Geological Survey and U.S. Forest Service personnel saw a new extrusion about one quarter the size of the October dome and emerging from its southeast edge. A spinelike structure protruding 30–60 m from the center of the October dome was noted an hour later. All but 8 m of this structure toppled the next day at 1540. Growth of the new southeast lobe and another much smaller new lobe on the northwest edge of the October dome had apparently stopped by January 3, but crater floor deformation has continued (see below). The southeast lobe measured at least 225 m in an east-west direction and reached a maximum height of about 100 m above the crater floor, although by January 6 the crest was subsiding somewhat. The northwest lobe was about 100 m across. By comparison, the elliptical October dome was about 230 m in largest horizontal dimension and 50 m high on October 19. A collapse pit formed on the October dome during the growth of the new lobes, but the pit's dimensions were not available.

Deformation measurements showed that the northern crater rampart had moved outward about 85 cm between December 23 and 28 and another 1.5 m by January 2. Since then, the crest of the rampart has been uplifted and thrust northward dramatically, as much as 5 m by January 6. Other thrusts have been observed in relatively level terrain on the crater floor.

By the afternoon of December 29, seismicity had declined to a rate of one or fewer events per hour. As of January 7, no harmonic tremor and very few discrete earthquakes were being recorded.

Information contacts: Don Swanson, Chris Newhall, and John Dvorak, U.S. Geological Survey Field Office, 301 E. McLaughlin, Vancouver, Washington 98663.

Steven Malone, Elliot Endo, and Craig Weaver, Graduate Program in Geophysics, University of Washington, Seattle, Washington 98195.

Robert Tilling, U.S. Geological Survey, Stop 906, National Center, Reston, Virginia 22092.

Krafla Caldera, Myvatn Area, Iceland (65.71°N, 16.75°W). By the end of November, inflation at Krafla brought ground level to the point at which previous deflation events and eruptions had been triggered. Ground level remained about the same until December 25 when 4 days of very slow deflation began. Total deflation was about one third the amount recorded during the October eruption. At the end of the deflation episode a swarm of small indistinct earthquakes was recorded, with epicenters about 10 km N of the caldera center. Inflation resumed on December 29, and by January 8 the caldera had nearly returned to its predeflation ground level.

Information contact: Gudmundur Sigvaldason, Nordic Volcanological Institute, University of Ireland, Reykjavik, Iceland.

Sakurazima Volcano, Kyushu, Japan (31.35°N, 130.65°E). Explosions from the summit crater of Minamidake began in October 1955 and were continuing at the end of 1980. The nine explosions in December brought the year's total to 276 (see Tables below), the largest number since 362 were recorded in 1974. (See *SEAN Bulletin*, 5(6) for a tabulation of monthly and yearly explosion figures since 1955). The highest December ash cloud rose 1.8 km on the 3rd.

Explosions from Sakurazima, December 1980

	December							
Date	3	5	10	13	18	20	23	Total
Number of explosions	1	2	1	2	1	1	1	9

Number of Explosions per Month at Sakurazima, January-December 1980

Month	Jan	Feb	Mar	Apr	May	June
Number	12	20	10	48	69	12
	July	Aug	Sept	Oct	Nov	Dec
	16	34	21	4	21	9
			Total 276			

Airshocks and tephra-fall from the explosions broke windows in buildings, automobiles, and aircraft; disrupted traffic; and interrupted electric power on occasion in 1980, but caused no injuries.

Information contact: Seismological Division, Japan Meteorological Agency, 1-3-4 Otemachi, Chiyoda-ku, Tokyo 100, Japan.

Kutinoerabuzima Volcano, Ryukyu Islands, Japan (30.43°N, 130.22°E). The following from the Japan Meteorological Agency supplements the reports of the September 28 eruption of Kutinoerabuzima in *SEAN Bulletin*, 5(9).

After the 28 September eruption, which lasted for ½ hour, no additional eruptions had occurred as of the end of December.

Eight scientists from Kyoto University, Kagoshima University, and the Japan Meteorological Agency observatory arrived at the island on 1 October, installing portable seismometers at 5 sites. The next day, they climbed to the new fissure, which was 0.6–6.0 m wide and 750 m long, trending N–S near Shindake crater (see Figure 1), active in historic time. A considerable amount of white vapor was emitted from the fissure.

The SW sector of the volcano was covered with gray ash, 1 m thick near the fissure and 2 cm thick at the base of the volcano, on the coast. Blocks were scattered N and W of the fissure, the largest block measuring about 2 m in diameter. No essential ejecta were observed. The volume of ejected material was estimated to be about 10^5 m³. Steaming decreased gradually during October, and was restricted to 10 small craters on the fissure by mid-October.

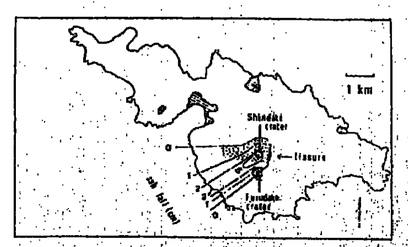

Fig. 1. Sketch map of Kutinoerabuzima Island, September 28, 1980. (Courtesy of the Japan Meteorological Agency.) Ashfall isopachs are in centimeters. Blocks fell in the stippled area. Shaded zones are inhabited.

(News cont. on page 52)

(News cont. from page 51)

Seismicity was relatively weak in October and November except on 4 and 9 October when swarms of small B-type earthquakes were recorded (see Figure 2). The Japan Meteorological Agency's seismometer was removed on 15 November because the volcano was quiet.

People on the island reported no felt earthquakes, and decreasing steam activity through December. Life returned to normal for the island's 300 inhabitants soon after the 28 September eruption.

Information contact: Same as for Sakurazima.

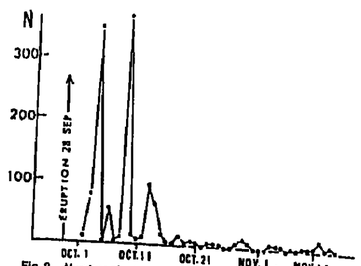

Fig. 2. Number of seismic events per day at Kutinoerabuzima, October 1–November 15, 1980. (Courtesy of the Japan Meterological Agency.)

Submarine Volcanos, Volcano Islands area, North Pacific Ocean. The Japan Maritime Safety Agency (JMSA) continues frequent aerial monitoring of several known submarine volcanos (see Table 1). Renewed activity at Myojinsho was first observed from a fishing boat on November 15. Observations at Fukutoku-oka-no-ba, Minami-hiyoshi, and Fukujin April 24–October 21 are summarized in last month's *Bulletin*. Nikko, last seen active in July 1979, was not observed by the JMSA in November or December.

Information contact: Same as for Sakurazima.

TABLE 1. Volcanic Activity at Four Sites in the Volcano Islands Area, November–December 1980

Volcano	Nov. 14	Dec. 18	Dec. 23
Myojinsho (31.92°N, 139.92°E)	—	—	D
Fukutoku-oka-no-ba (24.28°N, 141.52°E)	D	D	—
Minami-hiyoshi (23.50°N, 141.90°E)	N	N	—
Fukujin (21.93°N, 143.47°E)	N	N	—

D—discolored water observed; N—no discolored water visible; —no overflight.

Suwanosezima Volcano, Ryukyu Islands, Japan (29.53°N, 129.72°E). Strombolian explosions have occurred almost every month since November 1958 from Otake, the highest point on Suwanosezima Island. Eruptive activity has typically lasted from one to a few days. The only damage from the 1980 explosions was caused by minor ash falls on crops. Between explosive periods, white vapor rose a few hundred meters above the vent.

Information contact: Same as for Sakurazima.

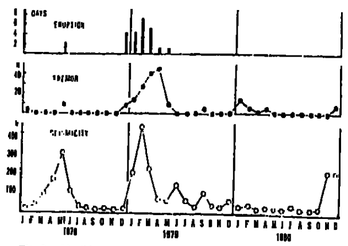

Fig. 3. Monthly numbers of days in which eruptions occurred (top), harmonic tremor events (center), and recorded earthquakes (bottom) at Tarumai, January 1978–December 1980.

Volcanic Activity in Nicaragua, El Salvador, and Guatemala–Late 1980

Geologists from Dartmouth College, the Instituto Geográfico Nacional of Guatemala, and the Instituto de Investigaciones Sísmicas of Nicaragua observed eight Nicaraguan, two Salvadoran, and two Guatemalan volcanos between mid-November and early December. Dartmouth geologists provided the following report.

Nicaragua

Cerro Negro (12.52°N, 86.73°W). Summit crater fumaroles remained at temperatures as high as 300°C. A small vapor plume was intermittently visible. Seismic activity had dropped from the high level of June.

Cosiguina (12.97°N, 87.58°W). No fumarolic activity was visible from the rim.

Las Pilas (El Hoyo) (12.48°N, 86.68°W). A small continuous vapor plume was still being emitted from the top of the kilometer-long crack in the summit.

Masaya (11.95°N, 86.15°W). Emission of a very large gas plume has continued without interruption since fall 1979. Remote sensing of SO_2 revealed continued high-level flux, with 1500–2000 tons/day average for the entire year. The hole through the surface of the lava lake was larger than in previous years, and a great deal of sublimation was occurring around its edge. No lava or red glow was visible during daylight. Acid gas and rain continued to cause considerable damage downwind.

Mombacho (11.83°N, 85.98°W). A small intermittent plume was visible, rising from the southeast section of the summit.

Momotombo (12.42°N, 86.55°W). The summit crater fumaroles continued to be very hot, with temperatures measured up to 735°C and reported to >900°C. A small vapor plume continued, and remote sensing revealed very low rates of SO_2 emission. Portions of the crater were seen to glow red and orange when observed at night, with the highest temperatures on the steep south wall of the crater. No seismic activity has occurred recently at Momotombo.

San Cristóbal (12.70°N, 87.02°W). A moderate-sized vapor plume rose continuously from the summit. Remote sensing of SO_2 revealed increased flux since June 1980, but SO_2 emission remained far below the levels of the mid-1970's.

TABLE 2. Eruptive Activity from Otake, December 18, 1979–December 13, 1980

Date	Cloud Height, km	Activity
1979		
Dec. 18	0.3	three explosions
1980		
Feb. 5–6		about 10 explosions; incandescent column
Mar. 21–22	1.5	many explosions
Apr. 25–26	1.0	explosions; ash fall on inhabited areas
May 13	1.5	three explosions
May 18		six explosions; persistent ash ejection
Jun. 4–5	0.5	more than 25 explosions
Jul. 16–19	0.5	many explosions
Aug. 3–8	many explosions	several tens of explosions; incandescent column
Aug. 21–23	1.5	more than 20 explosions; incandescent column
Sep. 8–9	1.0	more than 1000 explosions
Sep. 20	1.0	three explosions
Sep. 24–27		more than 1000 explosions
Oct. 25–27	2.0	persistent ash ejection
Nov. 8–10	0.5	more than 1000 explosions
Nov. 29	1.5	persistent ash ejection
Dec. 13	0.5	explosions

Tarumai Volcano, Hokkaido, Japan (42.68°N, 141.38°E). Seismic activity at Tarumai increased in November after about 1½ years of quiet (see Figure 3). The most recent eruptive activity, weak ash emission December 1978–May 1979, accompanied an increase in seismicity.

Information contact: Same as for Sakurazima.

Mayon Volcano, southeast Luzon Island, Philippines (13.26°N, 123.62°E). All times are local (GMT + 8 h). A moderate quantity of dirty white steam rose weakly to 200 m above the crater rim on December 4 at 1247, accompanied by short-duration harmonic tremor on the Mayon Resthouse Observatory seismograph. Faint crater glow was first noted at 2315 the same day. Additional steam emission was observed December 12 and 14.

Harmonic tremor was first recorded at Mayon on August 16. Episodes of tremor and discrete earthquakes continued through December. Similar seismic activity preceded the 1978 eruption and accompanied crater glow in July 1979.

Information contact: Olimpio Peña, Acting Commissioner, Commission on Volcanology, 5th Floor, Hizon Bldg., Quezon Blvd. Ext., Quezon City, Philippines.

Taal (14.00°N, 120.99°E). Seismic activity at Taal increased in November after about 1½ years of quiet (see Figure 3). The most recent eruptive activity, weak ash emission December 1978–May 1979, accompanied an increase in seismicity.

Information contact: Same as for Sakurazima.

Telica (12.60°N, 86.87°W). A moderate-sized but continuous vapor plume rose from the summit crater. SO_2 flux was remotely measured and found to be approximately 150 tons/day.

El Salvador

Observations were made during a flight over the country.

Santa Ana (13.85°N, 89.63°W). A moderate plume rose from a bank of fumaroles on the southeast wall of the inner crater, very similar to its appearance in November 1978.

San Miguel (13.44°N, 88.27°W). A small, continuous vapor plume rose from the summit crater.

Guatemala

Pacaya (14.38°N, 90.60°W). A very small cinder cone had grown inside MacKenney Crater in the last 2 months. A large gas plume rose continuously from the summit.

Santiaguito (14.76°N, 91.55°W). Ash and gas eruptions from Caliente vent (at the eastern end of Santiaguito Dome) occurred irregularly over the 3-day period of observation, with intervals of ½ hour to 4 hours between eruptions. Most eruptions lasted 2–3 min and sent ash and gas columns to heights of several hundred meters to 1 km above the vent. Five millimeters of ash accumulated at the foot of the dome over one 12-hour period. Eruptions occasionally threw 10-cm blocks several hundred meters and ejected tephra to well above the summit of Santa Maria. Although not directly observed, the plug dome and blocky lava flow that was seen being extruded from Caliente vent in February was apparently still very active. Large avalanches of glassy material could be heard from Caliente vista many times per hour. Debris from these avalanches was visible in the barranca below Santiaguito.

Information contacts: Richard E. Stoiber, Stanley N. Williams, H. Richard Naslund, Lawrence L. Malinconico, and Mark Conrad, Department of Earth Sciences, Dartmouth College, Hanover, New Hampshire 03755.

Samuel Bonis, Instituto Geográfico Nacional, Avenida las Américas, 5–76, Zona 13, Guatemala City, Guatemala.

Arturo Aburto and Douglas Fajardo, Instituto de Investigaciones Sísmicas, Apartado Postal 1761, Managua, Nicaragua.

Earthquakes

Date	Time, GMT	Magnitude	Latitude
Dec. 7	1737	5.7 M_s	36.02°N
Dec. 17	1622	6.7 M_s	49.41°N
Dec. 19	0117	6.1 M_s	34.54°N
Dec. 22	1251	5.5 m_b	34.39°N

Longitude	Depth of Focus	Region
1.23°E	10 km	northern Algeria
129.61°W	10 km	west of Vancouver Island, Canada
50.70°E	shallow	north central Iran
50.49°E	32 km	north central Iran

The Algeria event injured 20 persons in the El Asnam area, which was devastated by earthquakes October 10 that killed thousands and left about 400,000 homeless. There were no reports of casualties or damage from the December 17 shock. The December 19 earthquake killed 26 persons. The nearby event 3 days later caused three deaths and 139 injuries, according to official reports.

Information contacts: National Earthquake Information Service, U.S. Geological Survey, Stop 967, Denver Federal Center, Box 25046, Denver, Colorado 80225 USA.

United Press International.

The Associated Press.

Earthquake Swarm

Siquijor Island, Philippines. A swarm of earthquakes began to be felt at Lazi, on the south coast of Siquijor Island, on December 17. By December 19, recorded events averaged 102 per hour, and several may have reached magnitude 4–5. Loud detonations reportedly accompanied the seismicity. The next day, 95 strong earthquakes were recorded, accompanied by more detonations, and about 5000 residents fled to nearby islands. Earthquakes continued, but in decreasing numbers, through the end of December.

Initial investigations by the Commission on Volcanology and others yielded epicenters about 1.7 km N35°E of Lazi, with depths of focus averaging 2.9 km. Event locations trended NNW. The commission believes that the seismicity was probably caused by movement along a normal fault in the east central part of the island. Seismic monitoring was continuing in early January.

Information contacts: John A. Wolfe, MCCPO, Box 1868, Makati, Metro Manila, Philippines.

Olimpio Peña, Acting Commissioner, Commission on Volcanology, 5th Floor, Hizon Bldg., Quezon Blvd. Ext., Quezon City, Philippines.

United Press International.

Fireballs

Western Australia, July 13, 1241 GMT (2041 Western Australia Standard Time). David Dans saw a magnitude 10 violet-blue fireball from Belmont (near Perth). The object first appeared near alpha Capricornis. It left a blue train that persisted for 48 s.

Information contact: Robert A. Mackenzie, 26, Adrian Street, Dover, Kent CT17 9AT England.

Western Australia, July 25, 1502 GMT (2302 Western Australia Standard Time). John Leonard and Mrs. J. Hughes and family observed a brilliant fireball from Wembley and Gosnells (near Perth). The meteor traveled from the constellation Scorpius to the western horizon, where it disappeared behind a cloud bank. It was much brighter than the gibbous moon present in the sky at the same time, and it lit up the landscape, tree tops, and cloud banks. A train persisted for about 3 s.

Information contact: Same as above.

Western Australia, August 3, 1555 GMT (2355 Western Australia Standard Time). Craig Willoughby of Belmont (near Perth) observed a fireball that first appeared as a very slow, reddish, magnitude +2 object in Delphinus (alpha 314°, delta +14°). After traveling about 10° of arc, it suddenly brightened to a dazzling white and increased in diameter to about ½° of arc. The meteor then continued through Capricorn, slowly fading before ending near gamma Grus (alpha 321°, delta −32°). At its brightest this fireball reached a magnitude estimated by Mr. Willoughby, an experienced observer, at −15, lighting the sky as if at sunset. A train persisted for 35 s, noticeably distorted by upper atmosphere winds, before it disappeared.

Information contact: Same as above.

Northern Italy, November 28, 1727 GMT.
Observers: Capt. Schwecke, F/O and F/E of Lufthansa flight LH 303 (Rome–Munich).
Location: 44.67°N, 11.38°E (10 km north of Bologna), aircraft course 030° magnetic, altitude 10.5 km.
First sighting: 090° magnetic, 30° above the horizon
Last sighting: 030° magnetic, 5° above the horizon
Duration: 3–4 s
Magnitude: −7
Color: green
The object looked like a very bright green star with a tail slightly bent toward the earth.
Information contact: Gerhard Polnitsky, Universitaets-Sternwarte, Tuerkenschanzstrasse 17, A-1180 Wien, Austria.

New Hampshire, USA, December 12, about 0820 GMT (0320 Eastern Standard Time). William D. Beal, Jr., of Jackson, New Hampshire, observed a brilliant meteor that traveled about 35° of arc from NNW to SSE in 6 s. The fireball began as a red streak, changed to an intense white streak for about half its path, then disintegrated into orange particles that turned bluish-white. After an intense blue flash, the meteor disappeared above the horizon. Mr. Beal heard no sounds.

Information contact: William D. Beal, Jr., Dundee Road, Jackson, New Hampshire 03846.

Wyoming, USA, December 23, 0445 GMT (22 December, 2145 Mountain Standard Time). A U.S. Geological Survey seismic net in Yellowstone National Park recorded an air shock similar in strength to a sonic boom but with an atypical arrival pattern. Using a speed of sound in air of ⅓ km/s, Andrew Pitt calculated a point of origin for the air shock at 20-km altitude over 44.53°N, 110.38°W (± several hundredths of a degree), in the Yellowstone Lake area. This point is ringed by seismic instruments, with the most distant to record the air arrival about 70 km away.

Several eyewitnesses in this sparsely populated area observed a brilliant fireball shortly before the air shock was recorded. In western Yellowstone Park, about 60 km from the calculated air shock origin point, a man with his back to the event saw the sky brightening, then turned to see a blue ball with some orange highlights fall vertically until it disappeared below the horizon. The ball was as brilliant as the light produced by arc welding. He heard a low rumble 2–4 min later. About 120–130 km to the north, a woman saw a white ball, about half the size of the full moon, falling on a path slightly east of vertical. The object had a blue-green tail about 3 times the length of the head. After it disappeared behind a ridge, she saw a bright flash. Persons in central Yellowstone noted a bright flash from indoors and heard sounds shortly thereafter. The North American Air Defense Command (NORAD) had predicted no reentries for this time and location.

Information contacts: Andrew Pitt, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.

R. A. Hutchinson, Old Faithful Station, West Yellowstone, Montana 59758. NORAD/OIP, Peterson AFB, Colorado 80914.

Wales, November 29, 2228 GMT. David Powell of the Cardiff Astronomical Society observed a fireball, just below alpha Pegasus, moving slowly toward beta Cygnus. The object had a circular white head about ¼ the diameter of the full moon. Powell estimated the fireball's magnitude at −8. He reported no train or sonic effects.

Information contact: Robert A. Mackenzie, 26, Adrian Street, Dover, Kent CT17 9AT England. ⊠

New Publications

Theory of Planetary Atmospheres: An Introduction to Their Physics and Chemistry

Joseph W. Chamberlain, *Int. Geophys. Ser.*, vol. 22, Academic, New York, 330 pp., 1978, $29.50.

Reviewed by Siegfried J. Bauer

The adjective 'planetary' has become more common in recent book titles. This is not surprising since, during the last decade, all planets in our solar system, with the exception of the outermost ones, have been visited by spacecraft. In two cases (Mars and Venus), probes have entered through the atmospheres, landing on the surface to make in situ measurements of planetary characteristics in addition to the remote sensing observations; by the mid-1980's, the Galileo entry probe will make in situ observations of Jupiter's atmosphere as well. Planetary research, once solely the domain of astronomers, is now also being practiced by geologists, geophysicists, and meteorologists. This field has become truly interdisciplinary and therefore requires the crossing of many of the traditional boundaries of science. Appropriate books can be of great help in such endeavors. *Theory of Planetary Atmospheres* by Joseph W. Chamberlain is such a book; it is intended, as its subtitle implies, as an introduction to the physical and chemical processes occurring in the gaseous envelopes of the planets.

The book is organized into seven chapters of about 30–50 pages each, including bibliographical notes and problems. The first chapter, 'Vertical Structure of an Atmosphere,' not only treats the standard hydrostatic equilibrium, but also gives a thorough discussion of radiative equilibrium, stratospheric heating and mesospheric cooling, and a short discourse on ionization, dissociation, and heat transfer in the thermosphere, with a brief summary of the atmospheric structure of Venus, Mars, and Jupiter.

Chapter 2, 'Hydrodynamics of Atmospheres,' treats the basic equations generally used in dynamic meteorology, the horizontal circulation of the troposphere including geostrophic winds and gradient flow, thermal winds (jet streams), and the propagation of planetary-scale disturbances, as well as vertical transport exemplified by molecular and eddy diffusion. It also provides examples on the circulation of the Venus atmosphere, the diurnal winds on Mars, and convection in the Jovian atmosphere. Recent observations by Pioneer Venus and the Voyager spacecraft, however, should provide new observational inputs for the theoretical models of the circulation of Venus and Jupiter. Unfortunately, the chapter lacks a discussion of thermosphere dynamics.

The third chapter, 'Chemistry and Dynamics of Earth's Stratosphere,' provides an introduction to its photochemistry, the catalytic destruction of ozone, as well as stratospheric motions, vertical mixing, and meridional circulation occurring in the earth's stratosphere. This chapter provides a concise summary of the 'ozone problem,' largely derived from the series of papers that appeared in the *Reviews of Geophysics and Space Physics*.

Chapter 4, 'Planetary Astronomy,' gives an excellent account of radiative transfer in an optically thick atmosphere, including isotropic and anisotropic scattering, the theory of atmospheric spectroscopy, photometry, and polarimetry of planets, with particular examples concerning the atmosphere of Venus.

The fifth chapter, 'Ionospheres,' gives a brief introduction to the theory of ionospheric layer formation (Chapman and Bradbury layers), a short account of ambipolar diffusion, *D* region ion chemistry, a treatment of the behavior of radio waves in an ionized atmosphere with examples of radio occultation and incoherent scattering, and a very brief summary of the ionospheres of Venus, Mars, and Jupiter (in the case of Venus, unfortunately, without the benefit of the comprehensive Pioneer Venus data). Topics such as the absence of thermal equilibrium between electrons and ions and the role of the magnetic field in ionospheric transport processes, however, are absent or merely hinted at.

Chapter 6, 'Airglows and Aeronomy,' gives an excellent account of airglow photometry, resonant and fluorescent scattering of sunlight, and the day-airglow of the planets, including emissions from hydrogen, helium, atomic oxygen, as well as molecular excitations from O_2, CO, CO_2^+, and emissions from alkali metals. A brief overview on planetary aeronomy treating chemical reactions in CO_2 atmospheres (Venus and Mars) and H_2-dominated atmospheres (Jupiter, Saturn) concludes this chapter.

The seventh and last chapter deals with the 'Stability of Planetary Atmospheres,' viz. the effects of particle escape from the gravitational field. A thorough discussion is given of the density distributions in quasi-collisional exospheres particularly as they relate to airglow observations, the role of collisions and radiation pressure in exospheres, departures from a Maxwellian distribution near the exobase, as well as charge exchange collisions in the hot plasmasphere. Atmospheric escape mechanisms and limiting flux and their role in the loss of hydrogen and helium from the atmospheres of Earth, Venus, and Mars, and the escape of oxygen from Mars owing to nonthermal processes, are also discussed. The chapter closes with a section on atmospheric evolution and climate, including a comparison of the atmospheres of Earth, Venus, and Mars, as well as an enumeration of processes implicated in changes of the terrestrial climate.

While the book, as a whole, contains a wealth of information, the best and most comprehensively treated chapters are those concerning topics of the author's personal research expertise. This book is more a collection of chapters on different (albeit related) topics than a monograph, particularly when compared with Chamberlain's classic book, *Physics of the Aurora and Airglow*, which appeared as volume 2 in the same series. The lack of cohesion of the chapters, however, is, at once, weakness and strength, since individual chapters can thus very well be used in isolation from the rest of the book. The excellent, partly annotated, bibliography and the work examples elaborating on some details of topics either covered or only briefly mentioned in the text help to alleviate the weaknesses of some of the chapters.

Chamberlain's book is a valuable addition to the literature on planetary science, with most of the chapters representing lucid introductions to topics required for a thorough understanding of planetary atmospheres. The book is well produced, and there are remarkably few typographical errors (a list of the major ones is being supplied by the author). On the basis of its overall merit, I can highly recommend this book to everyone interested in, or working on, problems of the physics and chemistry of planetary atmospheres.

Siegfried J. Bauer is with the NASA/Goddard Space Flight Center in Greenbelt, Maryland.

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU

Advances in European Geothermal Research, A. S. Strub, P. Ungemach (Eds.), D. Reidel, Boston, Mass., xvi + 1086 pp., 1980, $63.00.

The Ancient Sun—Fossil Record in the Earth, Moon and Meteorites, R. O. Pepin, J. A. Eddy, R. B. Merrill (Eds.), Pergamon, New York, xvi + 581 pp., 1980.

Astronomy and Astrophysics Abstracts, vol. 27, *Literature 1980, Part 1*, S. Böhme, U. Esser, W. Fricke, I. Heinrich, W. Hofmann, D. Krahn, D. Rosa, L. D. Schmadel, G. Zech (Eds.). Springer, New York, x + 939 pp., 1980, $69.70.

Brazilian Stone Meteorites, C. B. Gomes and K. Keil, University of New Mexico Press, Albuquerque, N.M., v + 161 pp., 1981, $20.00.

Catalog of Tsunami Photographs—Key to Geophysical Records Documentation, No. 13, J. B. Nelson, National Geophysical and Solar-Terrestrial Data Center, Boulder, Colo., iii + 52 pp., 1980.

The Coastal Almanac for 1980—The Year of the Coast, P. L. Ringold, J. Clark, W. H. Freeman, San Francisco, Calif., xvi + 172 pp., 1980, hardbound: $19.95, paper: $9.95.

A Concise World Atlas of Geology and Mineral Deposits, D. R. Derry, John Wiley, New York, 110 pp., 1980, $61.95.

The Conference on Satellite-Based Navigation and Remote Sensing of the Sea, C. C. Tscherning (Ed.), Den Danske Nationalkomite for den Internationale Union for Geodesi og Geofysik, Charlottenlund, Denmark, 122 pp., 1980.

The Continental Crust and its Mineral Deposits, Spec. Pap. 20, D. W. Strangway (Ed.), Geological Association of Canada, Waterloo, Ontario, viii + 804 pp., 1980, $30.00.

Descriptive Regional Oceanography, Pergamon Mar. Ser. vol. 3, P. Tchernia, Pergamon, New York, xviii + 253 pp., 1980.

Developments in Petroleum Geology—2, G. D. Hobson (Ed.), Applied Science Publishers, London, x + 345 pp., 1980, $70.00.

A Dynamic Stratigraphy of the British Isles—A Study in Crustal Evolution, R. Anderton, P. H. Bridges, M. R. Leeder and B. W. Sellwood, George Allen & Unwin, Boston, Mass., x + 301 pp., 1979.

The Future of American Agriculture as a Strategic Resource, S. S. Batie and R. G. Healy (Eds.), The Conservation Foundation, Washington, D.C., xv + 294 pp., 1980.

General Oceanography—An Introduction, 2nd Ed., G. Dietrich, K. Kalle, W. Krauss, G. Siedler, John Wiley, New York, xxi + 626 pp., 1980.

Geochemistry of the Lithosphere, A. A. Beus, MIR Publishers, Moscow, 366 pp., 1976, $10.00.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the issue required.

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POSITIONS AVAILABLE

Assistant Research Professor. A non-tenure track position in geological sciences at the University of Washington for a person qualified to run an active research program in ^{14}C dating. Experience with thermal diffusion ^{14}C enrichment technique, and knowledge of the application of Van de Graaff accelerators to ultra-high sensitivity ^{14}C mass spectrometry essential. Salary $17,000–$21,000. Curriculum vitae, including two references to be sent by February 15 to M. Stuiver, Search Committee, Department of Geological Sciences, AJ-20, University of Washington, Seattle, WA 98195.

The University of Washington is an Affirmative Action/Equal Opportunity Employer.

Boise State University. The Department of Geology and Geophysics anticipates two tenure track positions.

Field-oriented Structural Geologist with teaching or research interest in one or more of the following: economic geology, mineralogy, engineering geology, or geohydrology.

Geophysicist specializing in applied seismology with a second area of interest in either geophysics or geology.

Ph.D. is required for both positions. Send resume, with at least three references to Monte D. Wilson, Chairman, Department of Geology and Geophysics, Boise State University, Boise, Idaho 83725.

Boise State University is an affirmative action/equal opportunity employer.

Exploration Geophysicist/University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will hire an experienced exploration geophysicist to fill the Frank and Betty Schultz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions to exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 18 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019.

The University of Oklahoma is an equal opportunity employer.

Postdoctoral Position/Earth and Space Sciences Institute. To assist in analysis and interpretation of data from the Voyager Ultraviolet Spectrometer. Possible fields of research include the bound and extended atmospheres of Jupiter, Saturn, and Titan. Applicants should have a Ph.D. and expertise in several of the following areas: atmospheric physics, plasma physics, atmosphere—magnetosphere interactions, computer programming and simulation, and UV spectroscopy in the laboratory or space. Initial appointment for one year with the possibility for extension. Applicant should send resume, list of publications, and names of three references to Bill R. Sandel, Earth and Space Sciences Institute, University of Southern California, 3625 East Ajo Way, Tucson, Arizona 85713.

USCI is an equal opportunity/affirmative action employer.

Virginia Polytechnic Institute and State University. Igneous Petrology and Geochemistry/Research Associate. Origin and tectonic significance of granitic rocks. Project involves petrography, analytic chemistry, mineral chemistry, isotopic studies, and field mapping. Send resume to:

D. R. Wones, Chairman
Department of Geological Sciences
Virginia Poly. Inst. and St. Univ.
Blacksburg, VA 24061

The University is an equal opportunity/affirmative action employer.

Research Position/Utah State University. Applications are invited for the position of assistant professor or associate professor (tenure or research track), starting July 1, 1981. Applicants should have a Ph.D. in civil engineering or related sciences and demonstrated research ability in the mathematical modeling of water quality and quantity systems (deterministic and stochastic methods to hydro quality modeling and ground water analysis), with interest in salinity control applications. Responsibilities include: preparing proposals, directing research, testing and conducting short courses. Salary range from $23,000 to $32,000 (12-month basis), commensurate with qualifications and experience. Application deadline is April 1, 1981. Send resume and names and addresses of three references to: L. Douglas James, Director, Utah Water Research Laboratory, UMC 82, Utah State University, Logan, Utah 84322.

Utah State University is an affirmative action/equal opportunity employer.

Oceanographic Mooring Technician. The Marine Science Program at North Caroline State University (Raleigh) is expanding its oceanographic technical services group and is currently seeking a technician familiar with the design and deployment of deep-sea current meter mooring arrays, as well as with standard shipboard oceanographic sampling techniques.

Qualifications include a degree in science or engineering with some electronics background and two years field experience or an equivalent combination of education and experience. Salary commensurate with education and experience. Send resume and names of references to Personnel Services, North Caroline State University, P.O. Box 5067, Raleigh, NC, 27650.

An equal opportunity employer.

Hydrogeologist. An outstanding career opportunity with excellent potential for advancement is currently open for a top professional interested in applied research. Duties will include planning, designing and conducting broad-based groundwater resources investigations. Specialization in geochemistry including expertise derived from academic training or experience in hydrochemistry will be considered an asset. Demonstrated ability to plan and execute programs to study the evolution of geochemistry processes in groundwater flow systems, including the movement of pollutants through granular or fractured rocks, is required. Good writing ability is a must. District facilities include drill rig, sophisticated geophysical logging equipment, chemistry laboratory and in-house computer and publishing facilities. Excellent fringe benefits package. Minimum entrance salary $18,324 per annum depending on training and experience. Minimum qualifications include M.S. in hydrogeology or geochemistry or equivalent training and experience. Interested and qualified professionals are encouraged to apply to: Personnel, South Florida Water Management District, P.O. Box ___, West Palm Beach, FL 33402.

Equal opportunity employer.

Dynamical Oceanographer. Research position (non-tenure-earning track) as an adjunct (assistant) professor presently available in Department of Oceanography, Naval Postgraduate School (NAVPGSCOL). Position available for immediate occupancy, and can be held at least 24 months, possibly 36 months, or longer. Occupant's research efforts devoted to dynamical and synoptic study of oceanic fronts and eddies. Diagnostic modeling of oceanic frontal and eddy density and circulation structure is central task in initial phase. Computerized analysis of satellite remote sensing and other data is involved. Opportunities to participate in field experiments exist. Together with Fleet Numerical Oceanography Center and Naval Environmental Prediction Facility, NAVPGSCOL has access to excellent computer, data archival, library, remote sensing, and research vessel facilities in Monterey. Department of Oceanography has faculty of 15 and advises graduate study body of about 80. Emphasis of faculty and student research is upper ocean, coastal ocean, polar ocean, and air-sea interaction processes. Instructional and research programs are conducted in close collaboration with Department of Meteorology. Occupant will have minor involvement in instructional program. Doctoral degree in physical oceanography, dynamical or synoptic meteorology, applied mathematics, physics, or equivalent required. Salary determined by qualifications of successful candidate. Send curricula vitae, names and addresses of three references to Professor Christopher N. K. Mooers, Chairman, Department of Oceanography, Naval Postgraduate School, Monterey, CA 93940. Telephone (408) 646-2673. Interview visits for top candidates arranged as soon as possible.

An equal opportunity/affirmative action employer.

Physical Oceanographer/ Geophysical Fluid Dynamicist

Areté Associates, a growing research firm, located in Southern California, engaged in theoretical and empirical physical oceanography, is offering permanent, full-time positions. Candidates require Ph.D. (or equivalent experience) in physical oceanography or geophysical fluid dynamics. Salaries are competitive and negotiable, based on qualifications. Areté offers a fringe benefit package of superior quality. Qualified candidates should send resumé, salary history, and list of professional references to:

Personnel Administrator
Areté Associates
P.O. Box 350
Encino, CA 91316

An equal opportunity employer M/F.

Geophysicist North Carolina State University—Raleigh. The Department of Marine, Earth and Atmospheric Sciences invites applications for a presently available tenure track position in geophysics. Rank and salary are open, depending on qualifications and experience. A Ph.D. is required. Applied or exploration geophysics orientation are preferable; however, other specializations in geophysics also will be considered.

Primary responsibilities will include generating and conducting research programs as well as teaching graduate courses in geophysics. The department currently consists of 31 regular faculty members including 16 in the areas of geology and geophysics. Please send resume and names of three references to Prof. I. J. Won, Search Committee Chairman, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC27650, USA. We hope to make a final decision prior to May 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Endowed Chair/Clemson University. Applications are invited for the Charles Carter Newman Endowed Chair of Natural Resources Engineering. Applicants should have an earned doctorate in engineering and a proven teaching and research record in areas closely associated with natural resources. Applicant should possess sincere interest in the conservation and development of natural resources with concurrent environmental protection. This twelve-month position carries the title of professor of agricultural engineering. Starting salary is open.

Send application and resume to Dr. B. K. Webb, Head, Department of Agricultural Engineering, Clemson University, Clemson, SC 29631 before May 1, 1981.

An affirmative action/equal opportunity employer.

Scientists/Meteorologists/Engineers. Science Systems and Applications, Inc., (SSAI) has positions for programmers, analysts, scientists and engineers to engage in scientific modeling and data analysis activities in the areas of: 1. Plasma/ionospheric physics theoretical simulations 2. Atmospheric/oceanic sciences 3. Remote sensing & radiative transfer/scattering studies 4. Satellite data analysis 5. Weather/climate & severe storms studies 6. Atmospheric/fluid dynamics 7. Solar and planetary physics and astronomy 8. Computer image processing and systems displays 9. System software/hardware engineering 10. Nuclear fusion/fission and 11. Applied mathematics. These positions involve working with NASA/NOAA/NAVY scientists in metropolitan, Washington, D.C. area. A strong background in numerical simulations, and experience in working with large scale computers is required for entry level to senior scientist/engineer positions. SSAI provides a congenial academic environment, pays liberal fringe benefits and awards bonuses to its employees. Please send your resume with salary history and references to Science Systems and Applications Inc., The Aerospace Building Suite 140, 10210 Greenbelt Road, Seabrook, MD 20801.

Faculty Positions in Geology/University of Alabama. The Department of Earth Science is seeking applicants for a tenure track position at the assistant professor level. The Ph.D. degree is required. The selected person will teach one or more courses in geophysics at the undergraduate level, basic courses in earth science, will supervise senior independent research projects, will develop one or more elective courses in that person's specialty, and will develop a research program.

The Department of Earth Science consists of four full-time faculty and graduates approximately ten seniors each year. Equipment and facilities include a geochemical and sedimentation laboratory, rock preparation equipment, student and research petrographic equipment, Bison seismographic equipment, transit and alidade, drafting facilities, and computer equipment. Salary is competitive and commensurate with experience and education.

Applicants should send a resume, three letters of reference, and a brief discussion of research interests to Michael J. Nelson, Earth Science Department, University of Alabama in Birmingham, Birmingham, Ala. 35294, prior to May 1, 1981. The position will be available September, 1981.

The University of Alabama in Birmingham is an equal opportunity/affirmative action employer.

Geochemistry/Brittle Deformation, University of New Brunswick. The Department of Geology has a tenure track position available from July 1, 1981 at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students.

Applications will be accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or ore engineering.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Postdoctoral Research Associate. Oceanography Department of the Naval Postgraduate School seeks recent graduate to study the hydrodynamics, through numerical ocean modeling of the physical oceanographic processes active in the vicinity of the arctic ice edge off Alaska. Problem areas include the effects of the complex bathymetry on the circulation and frontal formation, the dynamics associated with interleaving of water masses at the ice edge, and the mechanisms involved in ice retreat. Research will be performed in the context of an observational program which has acquired data and developed insights over the course of several years.

Position is available March 1981 and is renewable annually. Salary depends upon qualifications. Send resume and the names and addresses of three references to Faculty Search Committee, Dept. of Oceanography, Naval Postgraduate School, Monterey, CA 93940.

Equal opportunity/affirmative action employer.

Sediment Transport/Geological Oceanography. A tenure track position is available in the Department of Marine, Earth and Atmospheric Sciences at the level of assistant or associate professor. Applicants should have a thorough understanding of sediment transport, and a general background in geological oceanography. A Ph.D. is required. The candidate will be expected to strengthen the graduate teaching and research programs. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of marine sediment transport. Applicants should forward a resume, including a list of courses taken/taught, and the names of at least three references to Dr. Charles A. Nittrouer, Chairman, Search Committee, P.O. Box 5068, NC State University, Raleigh, NC, 27650. Application materials should be sent by March 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Structural Geologist/University of California, Santa Barbara. Applications are invited for a tenure track appointment in structural geology to be filled during 1981–1982, subject to availability of funds. Rank dependent upon qualifications and experience, but preference will be given to the assistant professor level. Successful candidates must have Ph.D. degree and strong desire and commitment to teach and direct MA, Ph.D., and undergraduate students in both structural and field geology. He/she will be expected to develop a strong research program and obtain outside funding for its support. Additional duties may include teaching physical geology and summer field geology.

Please send resume and evidence of teaching and research proficiency, by March 31, 1981, and arrange for early submission of four letters of recommendation to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. (805) 961-3156.

The University of California is an affirmative action/equal opportunity employer.

Faculty Positions/University of New Orleans. The Physics Department of the University of New Orleans invites applications for two tenure track positions expected to be available August 1981. Rank and salary are to be commensurate with experience and training. The department has a policy of encouraging research activities in applied areas which are of mutual interest to the faculty and the local technical community. Candidates with background in computational physics, acoustics, and geophysics are especially encouraged to apply. Current research activities within the department include experimental atomic and molecular physics, solid state physics, cryogenic geophysics, hydrodynamics, and computational physics.

Applicants should send a resume to Edward L. Beason, Chairman, Physics Department, University of New Orleans, LA 70122.

The University is an equal opportunity affirmative action employer.

Queens College. Position for 1–2 years as sabbatical replacement starts September 1981. Specialties requested: geochemistry (organic, environmental, or exploration); exploration geophysics; groundwater geology. A Ph.D. required. Applications should include c.v. and three references. Send to D. H. Speidel, Department of Earth and Environmental Sciences, Flushing, NY 11367.

Queens College is an affirmative action/equal opportunity employer.

Faculty Position UCLA. Tenure faculty position—associate or full professor—in planetary atmospheric sciences. It is expected that an opening will soon become available for a senior scientist who has demonstrated accomplishment in the area of atmospheric sciences. Preference will be given to an individual whose interests are in atmospheric chemistry with particular stress on the composition and evolution of planetary atmospheres. The successful individual will have a joint appointment in the Department of Atmospheric Sciences and the Institute of Geophysics and Planetary Physics. Please send resumes to: Leon Knopoff, Institute of Geophysics, UCLA, Los Angeles, Calif. 90024.

UCLA is an equal opportunity/affirmative action employer.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, watershed sciences or in a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant.

Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523(303) 491-5298.

Deadline for receipt of applications is April 15, 1981.

CSU is an EOE/AA. E.O. Office: 314 Student Serv. Bldg.

Research and Data Systems, Inc./Scientific Programmers and Programmer Analysts. Immediate openings for persons with B.S. in science or math and at least two years experience with FORTRAN or PL/I on IBM systems. Work involves data processing and analysis from satellite based remote sensing systems. Experience with time sharing systems preferred. Also have openings for staff scientists with strong programming background. Send resume in confidence to Research and Data Systems, Inc., 9420 Annapolis Road, Lanham, MD 20801. Telephone: (301) 459-0001.

Geophysicist. The Geology Department at the University of Southwestern Louisiana in Lafayette, Louisiana invites applications for an anticipated research/teaching opening in geophysics. Responsibilities will include one-half time in seismic investigation of geopressured-geothermal reservoirs of South Louisiana and one-half time teaching geophysics and supervising graduate students. The successful applicant will be familiar with exploration seismic data acquisition, processing, and interpretation. The Ph.D. or Masters with experience, is required. Salary range is $23,000 to $35,000 per 12 month.

The position is expected to be filled in the Spring of 1981 or as soon as possible thereafter.

To apply please direct a resume, three letters of recommendation, and any other pertinent materials to: Dr. Gary L. Kinsland, Geology Department, University of Southwestern Louisiana, Lafayette, LA 70504

Von Braun Post-Doctoral Fellowship in Space Physics/University of Alabama in Huntsville. Appointment effective September 1981 in a tenure track assistant professorship with reduced teaching load during the first two years. Research specialty in astrophysics, planetary science or solar terrestrial physics. Research support available from UAH, NASA and Redstone Arsenal. Salary competitive. Recent Ph.D.s are invited to send resume, research plans and names of four references. Apply to: Von Braun Fellowship Committee, Office of Academic Affairs, University of Alabama in Huntsville, AL 35899

Equal opportunity in education and employment

Glaciologist/University of Washington. The University of Washington seeks applications for a tenure track position with the individual to be appointed as assistant professor jointly in the Department of Atmospheric Sciences and Geophysics program. Principal research interest of candidates should be directed toward geophysical or climate related study of snow or ice. Candidates specializing in physical processes in snow are of particular, but not exclusive, interest. All applicants should be committed to graduate level teaching, research advising, and innovative research emphasizing advanced experimental methods and rigorous physical analysis. Duties will include teaching one or two undergraduate courses per year in atmospheric sciences. The appointment starts in September 1981. A Ph.D. is required. For additional information call C. F. Raymond (206) 543-4914. Interested persons may send a resume and four letters of recommendation to Professor R. T. Merrill, Geophysics Program AK-50, University of Washington, Seattle, WA 98195.

Deadline for application is 31 March 1981.

An equal opportunity/affirmative action employer.

Program Manager/Meteorology. Oceanographic Services, Inc., is seeking qualified applicants for the position of program manager for meteorological studies. Applicants should have an M.S. or Ph.D. in meteorology or atmospheric sciences, plus experience in the field. A broad general knowledge of air pollution, and an understanding of the air pollution regulatory environment, is helpful. Interested persons should send resume, references, and salary history to R. C. Banks, Oceanographic Services, Inc., 25 Castilian Drive, Goleta, CA 93117.

Acadia University. The Department of Geology, Acadia University, is seeking a head, beginning July 1, 1981. Preference will be given to applicants with experience and research interests in petroleum geology and related fields and/or energy resources. Rank and salary will be appropriate to qualifications. The successful candidate will assume leadership of an established, vigorous and growing department with five faculty members, and over 100 B.Sc. and M.Sc. candidates. Responsibilities include teaching at undergraduate and graduate levels, and academic planning and development in the specialty area.

A letter of application together with a curriculum vitae and names of three referees should be sent by March 15, 1981 to Dr. Earnest E. Zeck, Dean of Science, Acadia University, Wolfville, N.S., B0P 1X0.

Structural Geologist. The Department of Geosciences of Purdue University invites application for a tenure track faculty position in structural geology, starting in August 1981. Rank and salary will be commensurate with qualifications. A Ph.D. is required. The individual will be expected to teach undergraduate and graduate courses in structural geology and tectonics, participate in summer field courses, and pursue an active research program. Preference will be given to a candidate with an applied field orientation and a strong background in the quantitative analysis of field data. The department has active programs in petrology, geophysics, and engineering geology and has a close working relationship with the geotechnical group in civil engineering and the Laboratory for Applications of Remote Sensing. Closing date for application is April 1, 1981. Applicants should send a resume, the names, addresses, and telephone numbers of three referees, and a brief statement of research interests to R. H. McCallister, Department of Geosciences, Purdue University, West Lafayette, IN 47907.

Purdue University is an equal opportunity/affirmative action employer.

Staff Scientists/Ocean Margin Drilling Program. Joint Oceanographic Institutions, Inc. (JOI, Inc.) has immediate openings for two staff scientists to fill the positions of:

-Field Programs Coordinator
-Downhole Measurements Coordinator

In its Ocean Margin Drilling (OMD) Science Programs Office. Individuals filling each of these positions will report to the OMD Chief Scientist. They will be required to provide staff support to advisory committees in their area of concern, and will be responsible for implementing programs recommended by the OMD Science Advisory Committee, including oversight of the performance of individuals or groups under contract to JOI. Both positions require a Ph.D. in an appropriate area of earth science and appropriate experience. The OMDP is funded for FY 81. Initial appointment will be for a period of two years with the second year contingent upon the availability of funds. The positions may be filled on a rotating basis. Salary will be competitive. Send resume statement of interest, and the names of three referees to Thomas A. Davies, Chief Scientist, Ocean Margin Drilling Program, Joint Oceanographic Institutions, Inc., 2600 Virginia Ave, NW, Suite 512, Washington, DC 20037. The deadline for applications is February 20, 1981, or as soon thereafter as suitable candidates are found.

COURSES

Flood, Predictions, and Forecasting. June 29 to July 3, 1981. The objective is to present various methods for floods by well known lecturers. Physical understanding will be emphasized. Lecture notes are specifically written for this course. Contact H. W. Shen, Course Director, ERC, Colorado State University, Fort Collins, CO 80523, USA. Telephone (303) 491-8552; TWX 810-930-9000 ENGR CSU FTCN.

Statistical Techniques for Data Generation and Forecasting in Hydrology and Water Resources, July 6 to July 10, 1981. Fee: U.S. $525.00.

Contact: Dr. Jose D. Salas, Course Director, Engineering Research Center, Colorado State University, Fort Collins, Colorado 80523, USA Telephone: (303) 491-8460, Telex: 910 930 9000, ENGR CSU FTCN.

Lectures include: Univariate and multivariate modeling of hydrologic time series, AR and ARMA models, disaggregation modeling of single and multiple series, statistical techniques for forecasting, Kalman filtering estimation techniques and computer programs.

Lecturers are: Dr. R. Bras (M.I.T.); Dr. J. Delleur (Purdue University), Dr. W. Lane (U.S.B.R.), and Drs. V. Yevjevich, D. Boes, J. Labadie, and J. Salas (Colorado State University).

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AGU

Meteorology Section Considers New Name

The AGU Meteorology Section business meeting was held at the Jack Tar Hotel, December 9, during the AGU Fall Meeting in San Francisco. The principal item discussed at the half-hour meeting was the proposal made by several members that consideration be given to renaming the section 'Atmospheric Science.' The members present felt the proposed name would better serve the strong physical, chemical, and electrical constituencies now in the Meteorology Section. There was also some indication that those now in the SPR: Aeronomy Section would be interested in joining a revamped Atmospheric Science Section.

The consensus of the meeting was that this issue be pursued further by the officers of the Meteorology Section with other appropriate officials of AGU. The possibility of forming a small committee to define this proposal more precisely was also favored by the attendees.

Those attending were Tommy Augustsson, Old Dominion University; Bill Boeck, Niagara University; Jack Fishman, NASA/Langley; T. E. Graedel, Bell Laboratories; Joel S. Levine, NASA/Langley; Stan Ruttenberg, NCAR; Russ Schnell, NOAA/ARL; Rich Stolarski, NASA/Goddard; Ron Taylor, NSE; and Jay S. Winston, NOAA/NWS.

Jay S. Winston, *Secretary*
Meteorology Section

Candidates for JGR-Blue Editor Sought

George L. Siscoe will complete his term as editor of the *Journal of Geophysical Research*—Blue at the end of 1981. A selection committee, chaired by Norman F. Ness, has been appointed to recommend candidates to the AGU president. Nominations for the editor for the space sciences section of JGR for the term 1982–1985 are now being accepted. Those who are interested in serving as editor, or who wish to suggest candidates, should send recommendations by April 15 directly to

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009
Attention: JGR Search Committee

Meetings

Indonesia Plans Krakatau Commemoration

To commemorate the 100th anniversary of the August 27, 1883 eruption of Mount Krakatau, the Indonesian Institute of Sciences (LIPI) is sponsoring a 2-year program of expeditions and research that will culminate in a symposium on or about August 27, 1983.

The scientific activities and the symposium will center on volcanology and geology, marine and terrestrial biology, oceanography, and social aspects related to the Mount Krakatau eruption which left 36,000 people dead.

Scientists and institutions wishing to participate in the program and the concluding seminar should submit their proposals directly to LIPI, JL. Teuku Chik Ditiro 43, Jakarta, Indonesia, attn: Didin Sastrapradja, Deputy Chairman for Natural Sciences.

Volcanics in the Atmosphere

A session on the role of volcanic emissions in atmospheric chemistry will be held during the IAMAP Third Scientific Assembly in Hamburg.

Contributed papers are wanted for the special session, slated for August 21 and 22. Topics desired include those concerning mechanisms of volcanic emissions, experimental data and fluxes of gaseous and particulate matter to the atmosphere, the fate of volcanic products in the atmosphere, and the possible effects on the physics and chemistry of the atmosphere and future climate changes.

Abstracts should be sent to S. Ruttenberg, Secretary General of IAMAP, NCAR, P.O. Box 3000, Boulder, Colorado 80307; deadline is March 2. Copies of the abstracts should also be sent to coconvenors Gerard Lambert, at Centre des Faibles Radioactivites, Domaine du C.N.R.S., F 91190 Gif-sur-Yvette, France; and John W. Winchester, Department of Oceanography, Florida State University, Tallahassee, Florida 32306.

Baltimore
AGU Spring Meeting
May 25-29

Call for Papers

Abstract Deadline: March 4

Abstracts must be received at the AGU office by 5 P.M. on March 4 to be on time. Late abstracts (1) may be summarily rejected by program chairman, (2) may not be published in advance of the meeting, and (3) if accepted, will be charged a $25 late fee in addition to the regular publication charge.

General Regulations

Abstracts may be rejected without consideration of their content if they have not been received by the deadline or are not in the proper format. Abstracts may also be rejected if they contain material outside the scope of AGU activities or because they contain material already published or presented elsewhere. ONLY ONE CONTRIBUTED PAPER BY THE SAME FIRST AUTHOR WILL BE CONSIDERED for presentation; additional papers (unless invited) will be automatically rejected.

Only AGU members may submit an abstract. The abstract of a nonmember must be accompanied by a membership application form (with payment), or it must be sponsored by an AGU member.

A publication charge of $40.00 for each contributed abstract will be invoiced ($20.00 if the first author is a student member and if the appropriate notation is made on the abstract when submitted.) Both invited and contributed papers are subject to the publication charge unless specifically waived in writing. To repeat, the abstract must be received at AGU by March 4 to avoid an additional $25.00 charge. If a revised version of an abstract must be published, it will also be assessed a $25.00 charge.

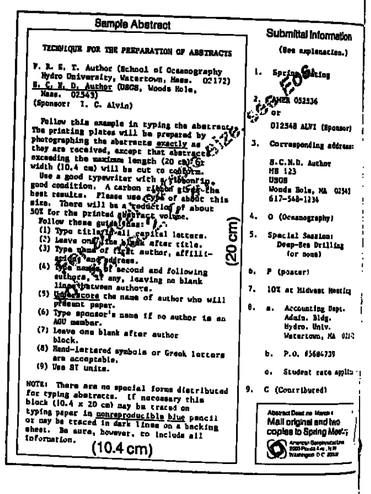
Authors will be notified by mail in late April of the status of their papers. Receipt of all papers will be acknowledged.

Ten minutes is normally allowed for the presentation of each contributed paper, and only 2" × 2" (35-mm) slide projectors and viewgraphs are usually available as standard equipment at the meeting. All other equipment is available at cost plus a $10.00 billing charge if we have to invoice.

Instructions for Preparing Meeting Abstracts

The abstract page is divided into two parts: the abstract itself and the submittal information. Follow the instructions for both carefully. Please use a carbon ribbon to type the material, and do not exceed the maximum dimensions of the abstract of 10.4 cm by 20 cm. Abstracts that exceed the noted size limitations will be trimmed to conform to the proper dimensions.

The meeting program will be prepared by photographing the abstracts exactly as they are received. Use the model abstract to prepare the final version. Submission of an abstract for an AGU meeting is presumed to carry with it permission for AGU to reproduce the abstract in all editions of *Eos* and in the programs and reports relating to the meeting; it is also presumed to permit the free copying of those papers. Although *Eos* is a copyrighted journal, authors are not requested to transfer copyright; copyright, where it exists, will be reserved by the authors.



Submittal Information

Numbers refer to the items in the submittal block on the sample abstract.

1. Title of meeting.

2. Identification. (Only members may submit an abstract; this includes invited authors.)—Type identification number of one member author (ID number is the line consisting of 4 letters followed by 6 digits; see member's mailing label on *Eos* or journals) or if no author is an AGU member, type the ID number of the member sponsor. (Sponsor's name must also appear on the abstract at the end of the author portion.) If no ID number is given, a membership application and dues payment must accompany the abstract. Call AGU Member Programs (202-462-6903) immediately if you need an application.

3. Corresponding address.—Give complete address and phone number of author to whom all correspondence (acknowledgment and acceptance letters) should be sent. Abbreviate as much as possible.

4. Section of AGU to which abstract is submitted.—Use letter abbreviations of one of the following: G (Geodesy), GP (Geomagnetism and Paleomagnetism), H (Hydrology), M (Meteorology), O (Oceanography), P (Planetology), S (Seismology), SA (Aeronomy), SM (Magnetospheric Physics), SC (Cosmic Rays), SS (Solar and Interplanetary Physics), T (Tectonophysics), VGP (Volcanology, Geochemistry, and Petrology), U (Union).

5. Type title of special session (if any) to which submittal is made.

6. Indicate your preference for a particular kind of presentation by one of the following letters: O for oral, P for poster. The chairman may assign your paper to either of these types of presentation in order to fit his program plan.

7. Percent of material previously presented or published, and where.

8. Billing information
a. Complete billing address if other than the corresponding address (item 3 above).
b. If purchase order is to be issued, indicate number. (Please have issuing department list name of first author and title of paper on PO.)
c. If student member is the first author, the student publication rate is applicable. Indicate 'student rate applicable.'

9. Indicate whether paper is C (contributed) or I (invited). If invited, list name of inviter.

Program Committee

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SPR-Magnetospheric Physics
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Tectonophysics
Mary Lou Zoback, USGS

Volcanology, Geochemistry, and Petrology
G. Brent Dalrymple, USGS

Special Sessions

Geodesy
Realization of a Conventional Terrestrial Reference System

Geomagnetism and Paleomagnetism
MAGSAT
Electromagnetic Induction Studies and Mantle Conductivity*
Geomagnetic Field Intensity Fluctuations During the Last 10,000 Years and Their Effects on Radiocarbon Production in the Atmosphere.*

Hydrology
John Ferris Symposium on Groundwater Hydraulics
Water Policies and Ground Water
Symposium on the EPA-USGS National Urban Runoff Program
Trace Organics in Groundwater
Public Water Supply
What Geochemistry Can Tell Us About Background Water Quality
The Efficacy of Modelling in Water Resources Planning and Management
Acid Rain: Assessment and Impact
Water: A Constraint on Synthetic Fuel Development?
Wetlands: A Threatened Resource
Desertification: Imagined or Real?

Planetology
Geological Processes on Icy Bodies (cosponsor: Tectonophysics)

Seismology
New Frontiers in Earth Structure: Anisotropy, Scattering, and Q.
Reflection and Refraction Seismology: Theory and Observation

SPR—Aeronomy
Field-Aligned Currents (cosponsor: SPR—Magnetospheric Physics, POSTER SESSION)*
History of Spectroscopy*

SPR-Cosmic Rays & SPR-Solar and Interplanetary Physics
Solar Flare Particle Acceleration
Solar Flare Particle Composition
Waves and Turbulence in the Solar Wind*

SPR-Magnetospheric Physics
Waves, Instabilities and Turbulence in Space Plasmas (POSTER SESSION).
Auroral Potential Structure*

Tectonophysics
Tectonics of Venus and Earth: A Comparison (cosponsor: Planetology and Geodesy).
Large-Scale Thin-Skin Tectonics (cosponsor: Seismology).
Illinois Deep Hole Project

Volcanology, Geochemistry, and Petrology
Silicate Melt Structure and Processes of Crystallization in Igneous Rocks
Precambrian Evolution of the Earth (cosponsor: Planetology and Tectonophysics).

SEASAT (cosponsors: Oceanography, Meteorology, and Geodesy).

*Additional Special Sessions

Session Highlights

Geomagnetism and Paleomagnetism

Electromagnetic Induction Studies and Mantle Conductivity. A special one-day session will be devoted to electromagnetic induction studies at the deep crust and upper mantle at sea and on land. Interaction of active scientists in the field with those making laboratory conductivity measurements will be emphasized. Interested persons are invited to contact Alan D. Chave, Geological Research Division A-020, Scripps Institution of Oceanography, La Jolla, CA 92093.

Geomagnetic Field Intensity Fluctuations During the Last 10,000 Years and Their Effects on Radiocarbon Production in the Atmosphere. A considerable amount of paleomagnetic work has recently been done on radiocarbon-dated lava flows, lake sediments, and archaeological material. As a result, certain models have been questioned by some workers. This has important ramifications for the correction to be applied to radiocarbon ages of all material datable by this method.

Planetology

Geological Processes on Icy Planetary Bodies (cosponsor: Tectonophysics). This special session will deal primarily but not exclusively with the Jovian satellites Europa, Ganymede, and Callisto. The submission of abstracts on geological characteristics and physical processes of surface and interior evolution is invited. For more specific information, contact E. M. Parmentier, Department of Geological Sciences, Brown University, Providence, RI 02912.

Tectonophysics

Tectonics of Venus and Earth: A Comparison (cosponsor: Planetology and Geodesy). The recent Pioneer mission to Venus has provided global information on the topography of Earth's twin planet and data on its gravity and magnetic fields. This special session will emphasize characterization of Venus and comparison with Earth. Specific emphasis will be on description, comparison, and interpretation of surface topography, lithospheric structure and evolution, thermal models, and gravity and magnetic fields. Organizer: James W. Head, Department of Geological Sciences, Brown University, Providence, RI 02912.

Large-Scale Thin-Skin Tectonics (cosponsor: Seismology). The following are subjects expected to be addressed in this session: large-scale detachments; sedimentary/accretionary wedges (including some that may contain large, allochthonous crystalline sheets); reactivation of passive, Appalachian-type margins; Paleomagnetic and other evidence for microcontinents and exotic blocks, and modes of their emplacement; continental growth by accretion; and implications for resource potential in overthrust belts. Some of the questions we wish to address in this session are: (1) Where and how widespread are large-scale detachments? (2) How do they affect the tectonics at plate boundaries and intraplate regions? (3) How are detachment structures formed? Can they persist as weakness zones through long geologic times? What are tectonic conditions for their reactivation? (4) What are the mechanisms of detachment slip, i.e., the rheologic and physical processes associated with active detachment structures? For additional information, contact Leonardo Seeber, Lamont-Doherty Geological Observatory, Palisades, NY 10964.

Illinois Deep Hole Project. Continuous core from three privately drilled deep holes in northern Illinois and access to one of these holes (1.6 km deep) were made available for scientific investigations through a steering group established in February 1980 by the U.S. Geodynamics Committee. The principal emphasis in the study of these deep holes, which penetrated about 1 km of Precambrian granite, was an integrated investigation of surface and in-hole experiments, as well as detailed petrologic and physical properties studies of the core samples. This special session will report on the results of some of these studies.

The in-hole experiments included in situ stress (hydrofrac) and permeability measurements as well as a complete suite of geophysical logs carried out to correlate with core studies. Core analysis includes investigations of the mineralogy, petrology, chemistry, ages, isotopic geochemistry, and geophysical properties of the rock. Surface geophysical investigations were conducted to delimit the extent of the pluton that was drilled into by the holes. (Organized by Bezalel Haimson, University of Wisconsin, Madison.)

Volcanology, Geochemistry Petrology

Precambrian Evolution of the Earth (cosponsor: Planetology and Tectonophysics). The purposes of the sessions are to bring together researchers in fields that bear on the development of the earth as a physical and chemical system and to integrate the ideas and data on terrestrial evolution from both the comparative planetology and earth-oriented approaches. The subject matter will include accretion and initial chemical segregation, thermal development, chemical and isotopic evolution, and tectonics of the atmosphere. Some papers will be invited but contributed papers are most welcome. For further information, contact the session organizers: Frank Eichler, Department of Geophysical Sciences, University of Chicago, Chicago, IL 60637 (312/753-8118), and Kevin Burke, Department of Geological Sciences, State University of New York, Albany, NY 12222 (518/457-3974).

Silicate Melt Structure and Crystallization Kinetics. This session will bring together researchers in the fields of silicate melt structure and melt crystallization kinetics to review recent development in these fields and to present new data. The topics to be discussed include investigation of melt structure by Raman and X ray spectroscopy and the investigation of the processes of nucleation and growth in both experimental and natural systems. Some papers will be invited, contributed papers are most welcome. For additional information, contact the session organizer, R. James Kirkpatrick, Department of Geology, University of Illinois, Urbana, IL 61801 (217/333-7414).

Geodesy/Meteorology/Oceanography

Description of SEASAT Sessions. The SEASAT sessions will emphasize scientific investigations that utilize data from the SEASAT satellite in the disciplines of oceanography, meteorology, geodesy and glaciology. Reports on novel algorithm development work that demonstrates significant improvements in geophysical extraction also are welcome.

Notice to SPR Section From President Norman Ness

We will carefully adhere to the standing rule of the AGU that an author may submit only one contributed paper at each meeting. The spirit of this rule is also meant to preclude groups of authors permuting their names on several papers to be presented in series so as to obtain more time. The program chairpersons of SPR will reject abstracts, or combine them if appropriate, in order to eliminate abuse of this rule.

Please note price change for SPR section luncheon: Cost per ticket, $3.50 (due to subsidy). See *Eos*, vol. 62, January 27, p. 39, for registration forms.

AGU Spring Meeting Flight Assistance to Baltimore

AGU will extend its arrangements with United Airlines to assist those attending the Spring Meeting in making their travel plans as economical and convenient as possible. The travel advisors at United are instructed to assist meeting attendees in making reservations and in getting the best possible airfare.

The method of payment and place of purchase of tickets is at the purchaser's option—by mail or by pickup at airline office, travel agency, or corporate travel office.

For personal assistance with the most up-to-date information on seat availability and possible special rates, call this unlisted toll-free number: 800/323-0639 (in Illinois, call 312/569-3375). Limited discount seats may be available.

Chapman Conference on Spatial Variability in Hydrologic Modeling

July 21–23, 1981
Colorado State University, Fort Collins

Purpose: The conference will provide a forum where surface and groundwater hydrologists, soil scientists, and applied statisticians can discuss progress and research approaches in dealing with spatial variability of catchment surface and subsurface properties in a distributed modeling context.

Call for Papers: Published in December 16, 1980, *Eos*. Includes program topics planned. Abstract deadline: May 15, 1981.

Convenors: D. A. Woolhiser and H-J. Morel-Seytoux.

Student Travel: Some travel money will be available to students. To apply, write to AGU, giving your educational background and your advisor's name. Briefly explain the reasons you wish to attend.

For further information, call or write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (telephone: 202/462-6903).

Travel Grants to IAGA and IAMAP Scientific Assemblies

Deadline for Applications: April 1

AGU has applied to the National Science Foundation for grants to assist the travel of individual U.S. scientists to the Fourth Scientific Assembly of the International Association of Geomagnetism and Aeronomy, to be held in Edinburgh, Scotland, August 3–15, 1981, and the Third Scientific Assembly of the International Association of Meteorology and Atmospheric Physics, to be held in Hamburg, Germany, August 17–28, 1981. Application forms for the grants are available from

Member Programs Division
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009
(Telephone: 202/462-6903).

Geophysical Year

(Boldface indicates meetings sponsored or cosponsored by AGU.)

1981

Feb. 22-27 American Society of Photogrammetry (ASP)-American Congress on Surveying and Mapping (ACSM) Annual Spring Meeting, Washington, D.C. (A. T. Cokonias, ASP Technical Program Committee, U.S.G.S., Reston, VA 22092; or Clyde R. Moore, ACSM Technical Program Committee, 9606 Duffer Way, Gaithersburg, MD 20760.)

Feb. 23-27 Third Dissertation Symposium in Chemical Oceanography, Hawaii. Sponsors, NSF, ONR, NOAA (Mary-Frances Thompson, Special Science Program, American Institute of Biological Sciences, 1401 Wilson Blvd., Arlington, VA 22209.)

March 9-12 ERRSAC/NOAA Land Remote Sensing Applications Conference, Danvers, Mass. Sponsors, NASA, NOAA. (Conference Management, Systems and Applied Sciences Corp., 6811 Kenilworth Ave., Riverdale, MD 20840.)

March 9-13 Symposium on Uncertainties Associated with the Regulation of the Geologic Disposal of High-Level Radioactive Waste, Gatlinburg, Tenn. Sponsors, U.S. Nuclear Regulatory Commission, Oak Ridge National Laboratory. (David C. Kocher, Bldg 7509, Health and Safety Research Division, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 37830.)

March 11-14 Conference on Comets, Gases, Ices, Grains, and Plasma, Tucson, Ariz. (L. Wilkening, Lunar and Planetary Laboratory, Univ. of Arizona, Tucson, AZ 85721.)

March 19-20 Tectonics and Ore Deposits Symposium, Tucson, Ariz. Sponsor, Arizona Geological Society. (John Reinbold, Conferences and Short Courses, Univ. of Arizona, 1717 E. Speedway Blvd., Tucson, AZ 85721.)

March 23-24 **Space Science Comes of Age: Perspectives in the History of the Space Sciences,** Washington, D.C. (Rita Bobowski, Public Affairs Officer, National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.)

March 23-27 International Symposium on Quality of Groundwater, Noordwijkerhout, The Netherlands. Sponsors, Unesco, World Health Organization, Commission of European Communities, International Association of Hydrogeologists, IAHS. (ISQG '81 c/o Kivi, P.O. Box 30424, 2500 GK The Hague, The Netherlands.)

March 24-26 Symposium on the Cerro Prieto Geothermal Field of Baja California, Mexico, San Francisco, Calif. Sponsors, U.S. Department of Energy, Commission Federal de Electricidad of Mexico, Univ. of California, Lawrence Berkeley Laboratory. (Werner Schwarz, Univ. of California, Lawrence Berkeley Laboratory, Earth Sciences Division, Berkeley, CA 94720.)

April 5-10 **Chapman Conference on Generation of the Oceanic Lithosphere,** Airlie House, Warrenton, Va. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

April 6-10 Second International Symposium on Flow, Its Measurement and Control in Science and Industry, St. Louis, Mo. Sponsors, American Society of Mechanical Engineers, Instrument Society of America, National Bureau of Standards. (Prof. William Durgin, Alden Research Laboratories, 30 Shrewsbury St., Holden, MA 01520.)

April 8-10 International Symposium on the Hellenic Arc and Trench, Athens, Greece. (Prof. S. S. Augustithis, International Symposium on the Hellenic Arc and Trench, National Technical Univ., Department of Mineralogy-Petrography-Geology, P.O. Box 1006, Athens, Greece.)

April 14-16 1981 Symposium on the Effect of the Ionosphere on Radiowave Propagating Systems, Alexandria, Va. Sponsors, Naval Research Laboratory, Air Force Geophysics Laboratory. (F. D. Clarke, NRL Code 4181, 4555 Overlook Ave., Washington, DC 20375.)

April 28-30 Symposium on Multidisciplinary Studies on Hudson/James Bay, Guelph, Ontario, Canada. Sponsor, Univ. of Guelph. (I. P. Martini, Department of Land Resource Science, Ontario Agricultural College, Univ. of Guelph, Guelph, Ontario N1G 2W1 Canada.)

April 30-May 2 10th Annual Rocky Mountain Groundwater Conference, Laramie, Wyo. (Peter Huntoon, Department of Geology, Univ. of Wyoming, Box 3006, Laramie, WY 82071.)

May 4-5 Seminar on Non-Sandstone Uranium Deposits, Golden, Colo. Sponsors, USGS, U.S. Department of Energy, Bendix Field Engineering Corp. (Geology Division, Bendix Field Engineering Corp., P.O. Box 1569, Grand Junction, CO 81502.)

May 4-8 13th International Liège Colloquium on Ocean Hydrodynamics, Liège, Belgium. Sponsors, IAPSO, Unesco Marine Sciences Division, EGS, Intergovernmental Oceanographic. (Jacques C. J. Nihoul, University of Liège, Mécanique des Fluides Géophysiques-Environment, B6- Sart Tilman, B-4000 Liège, Belgium.)

May 6-19 Annual Meeting, Mexican Geophysical Union, Manzanillo, Colima, Mexico. (Union Geofisica Mexicana, Comite Reunion 1981, Instituto de Geofisica, UNAM, Ciudad Universitaria, Mexico 20 D.F. Mexico.)

May 10-16 The Structure and Development of the Greenland-Scotland Ridge: New Methods and Concepts, Bressanone, Italy. Sponsor, NATO Advanced Research Institute. (Svend Saxov, Laboratory of Geophysics, Aarhus Univ., Finlandsgade 6-8, DK-8200 Aarhus N, Denmark.)

May 13-20 IUCRM Symposium on Wave Dynamics and Radio Probing of the Ocean Surface, Miami, Fla. Sponsors, NOAA, NASA, ONR. (G. Valenzuela, Physical Oceanography Branch, Environmental Sciences Division, Code 4344, Naval Research Laboratory, Washington, DC 20375.)

May 14-15 27th Annual Meeting of the Institute on Lake Superior Geology, East Lansing, Mich. Sponsor, Michigan State Univ. (F. W. Cambray, Department of Geology, Michigan State Univ., East Lansing, MI 48824.)

May 18-21 Rapid Excavation and Tunneling Conference, San Francisco, Calif. Sponsors, American Institute of Mining, Metallurgical, and Petroleum Engineers, American Society of Civil Engineers. (R. M. Orioglo, Assistant Conference Manager, Society of Mining Engineers, Caller No. D, Littleton, CO 80123.)

May 18-21 **The International Symposium on Rainfall-Runoff Modeling,** Mississippi State, Miss. (V. P. Singh, International Symposium on Rainfall-Runoff Modeling, Department of Civil Engineering, Mississippi State Univ., P.O. Drawer CE, Mississippi State, MS 39762.)

May 18-21 Proterozoic Symposium, Madison, Wis. Sponsor, Department of Geology and Geophysics, Univ. of Wisconsin-Madison. (L. G. Medaris, Jr., Department of Geology and Geophysics, Weeks Hall, Univ. of Wisconsin, Madison, WI 53706.)

May 25-29 **AGU Spring Meeting,** Baltimore, Md. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

May 25-29 International Tsunami Symposium 1981, Tsunami Commission of IUGG, Sendai-Ofunato, Japan. (E. Kajiura, Earthquake Research Institute, Univ. of Tokyo, Bunkyo-ku, Tokyo 113 Japan.)

May 27-29 Canadian Meteorological and Oceanographic Society 15th Annual Congress, Saskatoon, Saskatchewan, Canada. (B. E. Goodison, Program Chairman, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 Canada.)

June 1-5 **Second International Symposium on Inertial Technology for Surveying and Geodesy,** Banff, Canada. Sponsors, AGU, Canadian Institute of Surveying, Univ. of Calgary. (Klaus-Peter Schwarz, ISS Symposium 1981, Division of Surveying Engineering, Univ. of Calgary, Calgary, Alberta T2N 1N4 Canada.)

June 3-4 Symposium on the Ecology and Management of Reservoirs, Université Laval, Quebec, Canada. Sponsors, Unesco, Université du Quebec, Université Laval, Hydro-Quebec, Societé d'Energie de la Baie James. (P. G. C. Campbell, Université Quebec, INRS-Eau, C.P. 7500, Ste. Foy, Quebec G1V 4C7 Canada.)

June 4-5 Eastern Snow Conference, Syracuse, N.Y. (B. E. Goodison, Program Chairman, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario M3H 5T4 Canada.)

June 7-11 **Eighth Ocean Energy Conference for the Department of Energy,** Washington, D.C. Sponsor, Marine Technology Society. (Harry Irwin, Marine Technology Society, 1730 M St., N.W., Washington, DC 20036.)

June 8-10 **International Geoscience and Remote Sensing Symposium,** Washington, D.C. Sponsors, AGU, IEEE Geoscience and Remote Sensing Society. (F. T. Ulaby, Remote Sensing Laboratory, Univ. of Kansas Center for Research, Inc., West Campus, Lawrence, KS 66045.)

June 14-19 Second International Conference on Urban Storm Drainage, Urbana, Ill. Sponsors, Univ. of Illinois, International Liaison in Urban Storm Drainage, International Association of Hydraulic Research, International Association of Water Pollution Research, American Society of Civil Engineers. (B. C. Yen, Department of Civil Engineering, Univ. of Illinois, Urbana, IL 61801.)

June 15-19 International IEEE/APS Symposium, National Radio Science Meeting, and International IEEE/MTT Symposium, Los Angeles, Calif. (Prof. N. G. Alexopoulos, 7732 Boelter Hall, Department of Electrical Sciences, Univ. of California, Los Angeles, CA 90024.)

June 23-26 Seventh International Symposium on the Machine Processing of Remotely-Sensed Data, West Lafayette, Ind. Sponsor, Laboratory for Applications of Remote Sensing, Purdue Univ. (D. B. Morrison, Purdue Univ./LARS, 1220 Potter Dr., West Lafayette, IN 47906.)

June 24-26 International Symposium on Real-Time Operation of Hydrosystems, Waterloo, Ontario, Canada. Sponsor, Water Resources Group, Univ. of Waterloo. (T. E. Unny or E. A. McBean, Univ. of Waterloo, Department of Civil Engineering, Waterloo, Ontario N2L 3G1 Canada.)

July 6-11 Geocongress '81-South African Geodynamics Project and 3rd International Platinum Symposium, Pretoria, South Africa. Sponsors, Geological Society of South Africa, South African National Committee for the International Union of Geological Sciences, Society of Economic Geologists. (The Symposium Secretariat S. 217, CSIR, P.O. Box 395, Pretoria 0001 Republic of South Africa.)

July 8-10 National Conference on Environmental Engineering, Atlanta, Ga. Sponsor, Environmental Engineering Division of American Society of Civil Engineers. (F. Michael Saunders, 1981 National Conference on Environmental Engineering, School of Civil Engineers, Georgia Institute of Technology, Atlanta, GA 30332.)

July 21-23 Summer Computer Simulation Conference, Washington, D.C. Sponsors, American Meteorological Society, Instrument Society of America, the Society for Computer Simulation. (John A. Varela, MITRE Corp., 1820 Dolley Madison Blvd., McLean, VA 22102.)

July 21-30 21st General Assembly of IASPEI, London, Ontario, Canada. (A. E. Beck, Department of Geophysics, Univ. of Western Ontario, London, Ontario N6A 5B7 Canada.)

July 27-30 **Eighth International Symposium on Urban Hydrology, Hydraulics, and Sediment Control,** Lexington, Ky. (Don J. Wood, Department of Civil Engineering, 206B Anderson Hall, Univ. of Kentucky, Lexington, KY 40506.)

Aug. 3-15 IAGA Fourth Scientific Assembly, Edinburgh, United Kingdom. (B. R. Leaton, Institute of Geological Sciences, Edinburgh EH9 3LA United Kingdom.)

Aug. 4-7 International Conference on Energy Education, Providence, R.I. (Donald Kirwan, Conference Chairman, Office of Energy Education, Univ. of Rhode Island, Kingston, RI 02881.)

Aug. 9-15 Symposium on Variations in the Global Water Budget, Oxford, United Kingdom. Sponsors, ICCL, IAHS, INQUA. (Prof. R. E. Newell, Department of Meteorology, 54-1520, MIT, Cambridge, MA 02139.)

Aug. 10-14 International Conference on Basement Tectonics, Oslo, Norway. Sponsor, Norwegian Petroleum Society. (Roy H. Gabrielsen, Department of Geology, Univ. of Oslo, P.O. Box 1047, Blindern, Oslo 3 Norway; or Don L. Baars, Department of Geology, Fort Lewis College, Durango, CO 81301.)

Aug. 10-14 Water Forum '81: Technical State of the Art Exchange, San Francisco, Calif. Sponsors, American Society of Civil Engineers, Irrigation and Drainage Division, Committee on Drainage. (P. M. Meyers, 509 North Roosevelt Blvd., Apt. D-105, Falls Church, VA 22044.)

Aug. 10-19 20th General Assembly of the International Union of Radio Science, Washington, D.C. (R. Y. Dow, National Academy of Sciences, 2101 Constitution Ave., Washington, DC 20418.)

Aug. 17-28 Third Scientific Assembly of IAMAP with Extraordinary General Assembly, Hamburg, Federal Republic of Germany. (S. Ruttenburg, NCAR, P.O. Box 3000, Boulder, CO 80307.)

Aug. 17-18 Open Symposium on Mathematical Models of Radio Propagation, Washington, D.C. Sponsor, URSI. (J. R. Wait, Bldg. 20, Electrical Engineering Department, Univ. of Arizona, Tucson, AZ 85721.)

Aug. 17-22 Ninth International Symposium on Earth Tides, New York, N.Y. Sponsor, Columbia Univ. (J. T. Kuo, Aldridge Laboratory of Applied Geophysics, Henry Krumb School of Mines, Columbia Univ., New York, NY 10027.)

Aug. 18-21 Second Biennial Conference and Exhibition of the Australian Society of Exploration Geophysicists, Adelaide, South Australia. (J. Haigh, Conference Chairman, P.O. Box 42, Unley, South Australia 5061.)

Aug. 24-26 International Symposium on Management of Geodetic Data, Copenhagen, Denmark. Sponsors, IAG, the Danish National Committee of IUGG, Geodaetisk Institut. (C. C. Tscherning, International Symposium Management of Geodetic Data, Geodaetisk Institut, Gamlehave Alle 22, Charlottenlund DK-2920 Denmark.)

Aug. 28-Sept. 9 Arc Volcanism Symposium, Tokyo, Japan. Sponsors, Volcanological Society of Japan, IAVCEI. (Daisuke Shimozuru, IAVECEI Symposium on Arc Volcanism, Earthquake Research Institute, Univ. of Tokyo, Bunkyo-ku, Tokyo 113 Japan.)

Aug. 31-Sept. 5 Symposium on Geodetic Networks and Computations, Munich, West Germany. Sponsor, IAG. (Deutsche Geodätische Kommission, Bayerischen Akademie der Wissenschaften, Marstallplatz 8, D-8000 Munchen 22.)

Sept. United Nations Symposium on Water Management in Industrialized Areas, Lisbon, Portugal. (Chairman of the Executive Committee, International Symposium on Water Management in Industrial Areas, Portuguese Water Resources Association, c/o LNEC, Av. do Brasil, 101, 1799 Lisbon, Portugal.)

Sept. 7-12 Third International Symposium on Antarctic Glaciology, Columbus, Ohio. Sponsors, International Commission on Snow and Ice, International Glaciological Society. (Institute of Polar Studies, Ohio State Univ., 125 S. Oval Mall, Columbus, OH 43210.)

Sept. 13-17 National Water Well Association 33rd Annual Convention and Groundwater Technology Education Session, Kansas City, Mo. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.)

Sept. 16-18 **Oceans '81,** Boston, Mass. Sponsors, Marine Technology Society, IEEE Council of Oceanic Engineering. (R. Nagle, Publicity Manager, Raytheon Company, 141 Spring St., Lexington, MA 02173.)

Sept. 20-22 National Water Well Association 34th Annual Convention and Exposition, Atlanta, Ga. (NWWA, 500 West Wilson Bridge Rd., Worthington, OH 43085.)

Oct. 6-8 International Conference on Time Series Methods in Hydrosciences, Burlington, Ontario. Sponsors, National Water Research Institute of the Canada Centre for Inland Waters and Water-Resources Branch of Ontario's Ministry of Environment. (A. El-Shaarawi, Aquatic Physics and Systems Division, NWRI, Canada Centre for Inland Waters, P.O. Box 5050, Burlington, L7R 4A6, Ontario, Canada.)

Oct. 26-31 International Symposium on Quarternary Land-Sea Migration Bridges and Human Occupation of Submerged Coastlines, La Jolla, Calif. Sponsor, Center for Coastal Studies of Scripps Institution of Oceanography. (D. L. Inman, Director, Center for Coastal Studies, Scripps Institution of Oceanography, La Jolla, CA 92093.)

Nov. 2-6 International Conference on the Venus Experiment, San Francisco Bay Area, Calif. Sponsor, NASA. (Dr. Lawrence Colin, Ames Research Center, Moffett Field, CA 94035.)

Nov. 30-Dec. 11 43rd Session of the International Statistical Institute, Buenos Aires, Argentina. (Jim R. Wallis, IBM, Research Division, Box 218, Yorktown Heights, NY 10598; or G. S. Watson, Bernoulli Society for Mathematical Statistics and Probability, Department of Statistics, Princeton Univ., Princeton, NJ 08544.)

Dec. 7-11 **AGU Fall Meeting,** San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N.W., Washington, DC 20009.)

1982

April 19-21 Cordilleran Section, Geological Society of America and Seismological Society of America Annual Meeting, Anaheim, Calif. (Neil Maloney, Earth Science Department, California State Univ., Fullerton, CA 92634.)

May 3-7 14th International Liège Colloquium on Ocean Hydrodynamics, Liège, Belgium. Sponsors IAPSO, Unesco Marine Sciences Division, EGS, Intergovernmental Oceanographic. (Jacques C. J. Nihoul, University of Liège, Mecánique des Fluides Géophysiques-Environment, B6- Sart Tilman, B-4000 Liège, Belgium.)

May 7-20 General Meeting of IAG, Tokyo, Japan. (I. Nakagawa, Geophysical Institue, Kyoto University, Sakyo-ku, Kyoto 606 Japan.)

May 10-15 General Meeting of IAG, Tokyo, Japan. (M. Louis, IAG, 39 Rue Gay Lussac, 75005 Paris, France.)

June 27-July 2 Fifth International Conference on Geochronology, Cosmochronology, and Isotope Geology, Nikko National Park, Japan. (K. Shibata, Geological Survey of Japan, Higashi 1-1-3, Yatabe, Ibaraki 305 Japan.)

July 19-30 Scientific Meeting of IAHS with Extraordinary General Assembly, Exeter, United Kingdom. (John C. Rodda, Department of the Environment, Water Data Unit, Reading Bridge House, Reading RG1 8PS United Kingdom.)

FUTURE AGU MEETINGS

Fall Meetings
December 7-11, 1981, San Francisco
December 6-10, 1982, San Francisco
December 5-9, 1983, San Francisco

Spring Meetings
May 25-29, 1981, Baltimore
May 31-June 4, 1982, Philadelphia

IAG International Association of Geodesy
IAGA International Association of Geomagnetism and Aeronomy
IAHS International Association for Hydrological Sciences
IAMAP International Association of Meteorology and Atmospheric Physics
IAPSO International Association of Physical Sciences of the Ocean
IASPEI International Association of Seismology and Physics of the Earth's Interior
IAVCEI International Association of Volcanology and Chemistry of the Earth's Interior

Pacific Northwest Regional AGU Meeting

The 27th Annual Pacific Northwest Regional American Geophysical Union Meeting, held September 25 and 26, 1980, was hosted by the Pacific Geoscience Centre at the Institute of Ocean Sciences, near Victoria, British Columbia. A total of 79 papers was presented to the 150 registrants in six general sessions: seismology; electromagnetic induction; general geophysics; volcanology; hydrology; and oceanography, and in three special symposia: 'The Queen Charlotte-Fairweather fault system and other active faults of the Pacific Northwest'; 'Coastal circulation in the northeast Pacific;' and 'Studies of the eruption of Mount St. Helens.'

The organization fell largely to a local group that included Roy Hyndman (secretary treasurer), Robin Riddihough, Garry Rogers, Chris Yorath, Lawrie Law, and Kathy Fyfe, all of P.G.C., and Dave Krauel of Royal Roads Military College. The PNAGU upheld its record of providing the best conference value for money anywhere with a $15 advance registration fee that included bus transportation, a banquet with wine, and two lunches! The low registration fee was possible because of the meeting facilities provided by the Institute of Ocean Sciences; double-decker bus transportation provided by the Geological Survey of Canada; one lunch provided by the Province of British Columbia and a second by the Earth Physics Branch, Department of Energy, Mines and Resources; and because of a great deal of volunteer labor. At the banquet held in the Empress Hotel, Steve Malone of the University of Washington, Seattle, assisted by slides by Keith Ronnholm and several others, gave a dramatic (and amusing) overview of the Mount St. Helens eruption.

The Mount St. Helens session, with 23 papers presented, generated considerable interest from the news media as well as from the scientific community. The mountain was exhaustively examined, analyzed, poked, and probed by all manner of means, including earthquake studies, seismic structure, gravity, tilt, electrical properties, infrared scans, magnetic properties of the ash, composition of the ash, of flows, and of water, plus exhaustive photographic documentation. The impact of the eruption on the local hydrology and on the Columbia River was also reported extensively. Of particular interest was the University of Washington group, plus the U.S. Geological Survey and University of Montana reports on the earthquake patterns that occur during and as precursors to eruptions.

The papers on the Fairweather-Queen Charlotte fault system demonstrated that this system has been remarkably dynamic, with major fault shifts and reorganizations over the past few millions of years and components of convergence, as well as strike-slip transform motion. A grand and all encompassing picture of the complex microplate geological history of the whole region was presented by Chris Yorath and his associates in 'the apotheosis of Wrangellia.'

In the coastal oceanography session a spirited group debated aspects of shelf circulation along the West Coast and exchange with inlets and fjords.

This meeting report was prepared by Roy Hyndman, secretary-treasurer of PNAGU.

SEISMOLOGY

Thurs. Sept. 25. AM.

Auditorium

Chairman
B.T.R. Lewis,
Univ. of Washington,
Seattle.

SEISMICITY AND RATES OF MOTION ALONG FAULT ZONES

D.H. Weichert
R.D. Hyndman (both at: Pacific Geoscience Centre, Box 6000, Sidney, B.C., Canada, V8L 4B2)

An estimate for the total seismic moment and thus fault slip rate over a period of time may be obtained from the sum of the moments of the observed events. However, the apparent random occurrences, especially of the larger events, lead to large statistical errors. If the additional assumption of a frequency-magnitude relation can be justified, it may stabilize the estimate. Smith (1976) suggested to derive an estimate of maximum magnitude by comparing the integrated moment with geologically observed displacements. Molnar (1979) and Anderson (1979) used similar approaches. Similar techniques of stabilizing seismicity and seismic risk estimates through integration over recurrence relations have been suggested and used in a different context for some time, e.g. Cornell (1968), Anderson and Trifunac (1978) and by Weichert and Milne (1979).

We add another suggestion for exploring and utilizing the relation between slip rate and total moment and find that, contrary to the case of seismic risk, the largest contributions to moment always come from large M. Thus, not only the hypothetical maximum magnitude but the precise shape of the extrapolated recurrence curve near M_x have a strong effect. For instance, the difference between truncating the cumulative or the incremental magnitude recurrence curve amounts to a factor of 3.5 for the data from Reichle (1976) for the Gulf of California, with similar uncertainties for the Offshore area west of Vancouver Island and the Queen Charlotte fault.

SEISMICITY IN THE MICA RESERVOIR (McNAUGHTON LAKE) AREA, CANADA: 1973-1978

R.M. Ellis
B. Chandra (both at: University of British Columbia, Dept. of Geophysics and Astronomy, Vancouver, B.C., V6T 1W5)

Impoundment of McNaughton Lake was initiated on March 29, 1973 and full load of 25 X 10^9 m^3 and maximum depth 191 m first achieved in August 1976. The reservoir lies principally in the Rocky Mountain Trench, a major structural boundary between the Rocky Mountain Thrust Belt to the east and the Eastern Metamorphic Belt to the west. Although the regional seismicity is moderate, an average of about one $M_L \geq 3.0$ earthquake every two years in the period 1963-72, a magnitude 6 earthquake occurred adjacent to the present reservoir in 1918.

A monitoring program initiated in January 1973 has located 212 earthquakes with $M_L \geq 1.5$, the largest M_L=4.8. Most of the seismicity was confined to 4 sequences. The first swarm started prior to initiation of impoundment. The next 2 sequences occurred in the same area 17 km into the Rocky Mountains from the central section of the reservoir. The final sequence, consisting of the M_L=4.8 earthquake and its aftershocks, had a preferred epicentre very close to but east of the Rocky Mountain Trench near the northern section of the reservoir.

The overall spatial distribution of seismicity during the observation period was similar to the pre-loading pattern. Comparison of the data with that from reservoirs where seismicity has been induced shows that the observed seismicity is unlikely to have been induced.

McNAUGHTON LAKE SEISMICITY - MORE EVIDENCE FOR AN ANAHIM HOTSPOT?

Garry C. Rogers (Pacific Geoscience Centre, Earth Physics Branch, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2)

The only notable concentration of earthquakes in the Canadian Cordillera away from the coast occurs in the McNaughton Lake region of eastern British Columbia. Earthquakes have ranged in size from a magnitude 6 event in 1918 to recently detected swarms of microearthquakes. The location of this seismicity is directly off the end of the Anahim volcanic belt which strikes east-west across central British Columbia. The association of these two phenomena strengthens the hypothesis that the origin of the Anahim belt is due to North America overriding a mantle hotspot and provides a possible explanation for the concentration and character of the seismicity.

TIME TERM ANALYSIS OF REFRACTION DATA IN SOUTHERN BRITISH COLUMBIA AND NORTHERN WASHINGTON

Rohay, Alan C., Geophysics Program, Univ. of Washington, Seattle, WA, 98195 and Rockwell Hanford Operations, P.O. Box 800, Richland, WA, 99352.

Recent Pn refraction data in the Cascade Range and Okanogan Highlands were combined with previous published data in Washington and southern British Columbia to study regional variation in crustal structure. A data set was constructed by averaging travel times within ten regions from six sources, resulting in 21 observations (including origin times).

The time term method was modified to remove the distinction between source and receiver observations which can bias the solution. This produces an optimal and independent estimate of residuals, regardless of whether the data are origin times or arrival times.

The solution was found to be unstable with reference to varying the data used. Least squares inversion was done using constraints corresponding to a flat refractor, which were progressively relaxed to find the "optimal" solution.

This solution computes a velocity of 7.89 .07 km/sec. Relative to this velocity (which was stable), time terms varied 0.5 sec rms leaving 0.2 sec rms unexplained above the 0.2 sec accuracy assumed. Time terms were 3.5 sec in the western Cascades, 3.0 sec in the Okanogan Highlands and southern British Columbia, and 2.5 sec near the Columbia Plateau. Excluding Vancouver Island, these time terms are converted to crustal thickness by multiplication XII, using an average crustal velocity of 6.4 km/sec. A two-layer model (0-20 km 6.1 km/sec, 20 km-Moho 6.9 km/sec) gives similar results.

ANALYSIS OF DISPERSIVE WAVES BY WAVE FIELD TRANSFORMATION

G.A. McMechan
M.J. Yedlin (both at Department of Geophysics, Stanford University, Stanford, California 94305)

The dispersive waves in a common-shot wave field can be transformed into images of the dispersion curves of each mode in the data. The procedure consists of two linear transformations. A slant stack of the data produces a wave field in the phase slowness-time intercept (p-τ) plane in which phase velocities are separated. The spectral peak of the one-dimensional Fourier transform of the p-τ wave field then gives the frequency associated with each phase velocity. Thus, the data wave field is linearly transformed from the time-distance domain into the slowness-frequency (p-ω) domain, where dispersion curves are imaged. All the data are present throughout the transformations. Dispersion curves for the mode overtones as well as the fundamental are directly observed in the transformed wave field. In the p-ω domain, each mode is separated from the others even when its presence is not visually detectable in the untransformed data. The resolution achieved in the result is indicated in the p-ω wave field by the width and coherence of the image. The method is applied to both synthetic and real data sets.

DECONVOLUTION OF MARINE SEISMIC DATA USING THE ℓ_1 NORM

N.R. Chapman (Defence Research Establishment Pacific, FMO Victoria, B.C. V0S 1B0
I.C. Barrodale (Department of Computer Science, University of Victoria, Victoria, B.C.)

The trace measured in a marine seismic experiment can be expressed as the convolution of a source wavelet and a sparsely populated spike train which represents the impulse response of the medium. Deconvolution processing using the ℓ_1 norm criterion has been suggested by Taylor et al[1] to obtain estimates of the impulse response from noisy traces. This criterion is well-suited to problems where a spiky output is expected. In this paper we present a new ℓ_1 formulation of the deconvolution problem which represents a significant improvement over the concept proposed by Taylor et al[1]. The performance has been tested with synthetic data where gaussian noise has been added both to the trace and the source wavelet, and the results of these trials are described. An example is presented which demonstrates the success of this method in removing bubble pulse interference from a bottom-reflected acoustic signal.

1) H.L. Taylor, S.C. Banks and J.M. McCoy, 'Deconvolution with the ℓ_1 norm' Geophysics 44 39 1979.

VISP 80-A SEISMIC PROJECT TO STUDY THE OCEANIC/CONTINENTAL LITHOSPHERE TRANSITION ACROSS VANCOUVER IS.

G.D. Spence (Department of Geophysics & Astronomy, University of British Columbia, Vancouver, B.C., V6T 1W5) On behalf of CO-CRUST '80 participants*

During August 1980, a cooperative onshore-offshore seismic program with the final objective of providing a structural section of the lithosphere from the oceanic Juan de Fuca plate to the continental America plate was carried out. One refraction line with an average seismograph station spacing of 4 km was established along the length of Vancouver Is. Shots of 900 kg and 1800 kg were detonated at either end and in the middle of the island. A second refraction line with a similar average station spacing was established across south-central Vancouver Is. and up Jervis Inlet. Four ocean bottom seismometers (OBS's) extended this profile from the continental shelf to the deep ocean. Sources were two 825 kg charges in Jervis Inlet and a series of offshore shots through the OBS's. A second marine explosives profile, oriented perpendicular to the other at its western end, was shot into 3 OBS's deployed along the 110 km line. To obtain upper crustal information, a 32ℓ(2000 in^3) airgun was fired at two minute intervals over the OBS's. Initial playbacks indicate that nearly all data were well recorded throughout the project.

A second phase of the program was a feasibility study for deep crustal reflections on Vancouver Is. 12-fold coverage along a 10 km line was achieved. Additional data were obtained by repeated firing of the 32ℓ airgun along a 10 km line with 48-channel land-based recording. Monitor records show some coherent energy at least to 10s.

*Universities of British Columbia, Alberta, Saskatchewan, Manitoba and Western Ontario; Pacific Geoscience Centre; Atlantic Geoscience Centre; and Seismology Division, Earth Physics Branch.

GENERAL GEOPHYSICS

Thurs. Sept. 25. AM.

Auditorium

Chairman
R.M. Clowes,
Univ. of British Columbia,
Vancouver.

RAPID DIAGENESIS OF MARINE TURBIDITES IN THE WINONA BASIN

E.E. Davis (Pacific Geoscience Centre, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2)

The Winona basin is a young deep water basin along the base of the continental slope off central British Columbia which has been filled with turbidite sediments during the Pleistocene. Seismic reflection profiles in the basin indicate that in places the sediment thickness is well over 4.0 two way travel time seconds. Where seismic refraction lines (reported previously by Clowes et al.) cross or are nearly coincident with reflection lines, it is observed that velocities of over 5.3 km s^{-1} exist within the sediment section. The high velocities imply high densities and high degrees of lithification; these implications are verified by samples dredged from the basin, and the nature of the samples suggests a mechanism of lithification. Samples range from fine grained mudstones to coarse sandstones and conglomerates. The coarser grained rocks are all well cemented with calcium carbonate, with carbonate contents ranging up to 37%. Measured porosities are as low as 8%, but porosities calculated on a carbonate-free basis range from 35% to 55%, and this indicates that lithification is due almost entirely to cementation which must occur in the rapidly deposited sediments quickly before significant consolidation can take place. The refraction results substantiate this conclusion; velocities as high as 4.3 km s^{-1} were measured at depths as shallow as 1.8 km, and the age of the sediments at this depth is estimated to be only .5 m.y. If the carbonate is derived from saturated seawater (the source is probably not within the sediments), then the sediments must be permeable enough on average to allow the circulation of large quantities of seawater. One possible mechanism for driving pore water through the sediment is hydrothermal convection driven by the regional geothermal flux.

TRACE METAL GEOCHEMISTRY OF SEDIMENTS, NORTHEAST PACIFIC

B.D. Bornhold
D.L. Tiffin
R.G. Currie (all at: Pacific Geoscience Centre, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2)

Forty-two cores from the vicinity of the Juan de Fuca and Explorer Ridges in the northeast Pacific were analysed for Zn, Cu, Pb, Ni, Co, Mo, Mn, Fe and Ca. In all but one core, the trace element concentrations tend to be less than those of average Pacific pelagic clay.

The exception is a core located northwest of Explorer Ridge which penetrated dark brown sediments at the base of the sedimentary section. These sediments have trace element abundances comparable to those found in metalliferous sediments from the East Pacific Rise and elsewhere in the eastern equatorial Pacific. In view of the very high rates of pelagic and hemipelagic sedimentation, metal-rich sediments overlying basaltic crust are expected to be thin in the northeast Pacific or to be localized along fault scarps or near basement outcrops where hydrothermal fluids emanate.

ISOSTASY, MAGMA CHAMBERS AND PLATE DRIVING FORCES ON THE EAST PACIFIC RISE

B. T. R. Lewis (Dept. of Oceanography and Geophysics, Univ. of Washington, Seattle, WA 98195)

The density distribution within a cooling plate is calculated which incorporates temperature and pressure effects. From this density distribution the pressure field within the plate and the gravity field at sea level are computed. In this model the pressure field within the plate has a horizontal gradient at shallow depths away from zero age and a horizontal gradient toward zero age at greater depths caused by the loading of the ocean. Isostatic equilibrium is approached if one allows the loading due to the water to depress the seafloor and at the same time allows mass conservation by flow at depth toward zero age. It is found that for a homogeneous model a near zero free air anomaly does not occur for perfect isostatic compensation, resulting in residual pressure gradients toward zero age at depth. A viscosity model based on a Newtonian rheology which includes temperature and pressure effects has a high gradient close to the plane separating positive and negative pressure gradients which would facilitate the return flow and decouple the lithosphere from the asthenosphere. Addition of a crust to the homogeneous model does not substantially change these conclusions.

MARINE GRAVITY AND MAGNETIC SURVEYS OFF CANADA'S WEST COAST: 1980 PROGRESS REPORT

R.G. Currie (Pacific Geoscience Centre, Sidney, B.C.)
L.E. Stephens (Geological Survey of Canada, Ottawa, Ont.)

Systematic marine geophysical surveys in the Resources Mapping program in 1980 were concentrated in Hecate Strait, Dixon Entrance and the north-western portion of the 200 mile Economic Zone. In Hecate Strait and Dixon Entrance continuous gravity, magnetic and bathymetric profiling infilled previous work to bring coverage up to standard 5 km line spacing. In the N.W., profiles extended out to 139°W and delineate a major east-west transform just south of 54°N which can now be traced over 200 km.

A feature of the 1980 program was the testing of a prototype Lacoste & Romberg 'straight-line' gravimeter (SLL) alongside two 3 axis, 'beam-type' dynamic gravimeters (S41, S50). Preliminary results from a short calibration cruise across the gravity test range off Cape Flattery and the main Resource mapping surveys indicate very good comparisons between all 3 meters and a considerable reduction in 'cross-coupling' effects in SLL. A series of long survey lines crossing the previous marine gravity surveys in the region were observed and will allow a simultaneous adjustment of all marine gravity surveys to be carried out during the next few months.

GRAVITY SURVEY OF THE CASCADE MOUNTAINS OF WASHINGTON STATE

J. F. Danes (Physics Department, University of Puget Sound, Tacoma, WA 98416)

The Department of Energy, through the [illegible] of the U.S. Geological Survey and the Washington State Department of Natural Resources, has awarded the University of Puget Sound a grant to provide a gravity survey of most of the Washington Cascades. The purpose of the survey is to help locate resources of geothermal energy, but the application of the results is not limited to any particular goal.

Under that contract, about [illegible] gravity stations were established in 1979 and a comparable number in 1980, giving us a total of about [illegible] stations.

As far as possible, station spacing is held to 3 km or less; readings are taken at established elevation points; and sites are picked to minimize terrain effects.

True gravity values are probably good to about ±0.1 mgal. Uncertainty in elevation, station reduction density, and mainly terrain corrections, increase the probable error to about ±1.0 mgal in areas of more gentle topography, and somewhere between ±1.0 and ±5.0 mgal in the most difficult terrain.

Since the pre-1980 field work includes a detailed coverage of Mount St. Helens, a re-occupation of those points may give us a unique opportunity to analyze mass transport associated with a major volcanic eruption.

DATING QUATERNARY LAND SEDIMENTS BY THERMOLUMINESCENCE

G.W. Berger (Physics Dept., Simon Fraser University, Burnaby, B.C., Canada V5A 1S6)
D.J. Huntley, P.J. Mulhern

In an attempt to firmly establish the thermoluminescence (TL) method of dating land sediments we have investigated two principal questions: what conditions contribute to the "zeroing" of the TL clock, and what mineral components yield useful dates.

Application of our sunlamp bleaching technique to river silts gave unexpectedly high TL equivalent doses (EDs) which, however, could be reduced by changing the spectrum of the bleaching light. On the other hand, silts near the top of a soil profile did yield an effectively zero TL age with the normal bleaching.

Using a glacial till from the Toronto area (Sunnybrook till) we developed methods to isolate feldspar, quartz and magnetic fractions of 4-10µm size. The quartz yielded TL ages near 120 ka while a non-magnetic fraction gave a TL age near 45 ka, both geologically reasonable. To resolve this ambiguity we selected glaciolacustrine silts from the Kamloops area, B.C. (Gore Creek site) deposited 5-10 ka ago. Here the quartz ages were 17 ka and 30 ka while the non-quartz fractions did not have ED plateaus. This shortcoming was caused by TL peak shifts under laboratory irradiations. Correction for these shifts produced TL ages near 9 ka in all the feldspar-rich fractions. Applied to the glacial till, similar corrections yielded TL ages near 45 ka in all the non-quartz fractions.

From these preliminary results we conclude that the TL dating of land sediments is practicable for feldspar-dominated fractions provided that some as-yet-poorly-understood effects are accomodated. Presently, the TL ages from 4-10µm quartz do not appear to define known events.

HEAT FLOW IN JERVIS INLET SOUTHWESTERN BRITISH COLUMBIA

T.J. Lewis
R.D. Hyndman (both at: Pacific Geoscience Centre, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2)

Terrestrial heat flow has been measured using ocean probe techniques in Jervis Inlet over a distance of 45 km through the Coast Crystalline Complex of southwestern British Columbia. The measured values increase from 45 mW m^{-2} at the southwest mouth of the Inlet to 100 mW m^{-2} at the head at the north east. Large corrections are required for sedimentation, topography and uplift and erosion but they can not change the fact that the heat flow must change by a factor of two over this short distance. The data is consistent with a model of subduction with low heat flow in the arc-trench gap and high heat flow inland from the area of the volcanic arc. The high heat flows at the head of the inlet probably mark the western limit of the zone of high heat flow associated with the volcanic centres of Mt. Meager and Mt. Caley at the north end of the Cascade volcanic chain some 40 km to the east.

UPLIFT RATES OF MT. LOGAN, Y.T., AND BRITISH COLUMBIA'S CENTRAL COAST MOUNTAINS USING FISSION TRACK DATING METHODS

Parrish, Randall R. (Dept. of Geological Sciences, Univ. of British Columbia, Vancouver, B.C. V6T 1W5 Canada)

By dating apatites and zircons collected at various elevations at a location, uplift rates have been determined for various times in the mid-late Cenozoic. The method has also been used to estimate paleo-geothermal gradients.

Mt. Logan, in the St. Elias Mountains, has local relief of 4 km. Dates on apatite range from about 30 Ma at the summit (5950m) to less than 14 Ma at the 3790m level in the King Trench, and they indicate that an increase in uplift rate from 0.1mm/yr to ~0.3mm/yr occurred about 15 Ma ago. The massif's present rate is probably similar to its determined rate of 0.35mm/yr from 14-13Ma ago.

At Remano, near the eastern side of British Columbia's central Coast Mountains, topographic relief is about 2 km. Dates on minerals vary with decreasing elevation from 49 to 36Ma for sphene, 43 to 31 Ma for zircon, and 31 to 21Ma for apatite. These dates allow the inference that the uplift rate in the mid-Cenozoic (35Ma-24Ma) hovered around 0.1-0.15mm/yr. An increase to not more than 0.25mm/yr in the late Miocene-Pliocene is likely, contributing to the present topographic relief.

The difference in general physiography between these two areas reflects the difference in uplift rates that the two areas have experienced in the late Cenozoic.

QUEEN CHARLOTTE FAULT ZONE AND OTHER ACTIVE FAULTS

Thurs. Sept. 25. PM.

Auditorium

Chairman
R.M. Ellis,
Univ. of British Columbia,
Vancouver.

STRUCTURE OF THE CONTINENTAL SLOPE ALONG THE FAIRWEATHER FAULT SYSTEM, SOUTHEASTERN ALASKA

Terry R. Bruns (U.S. Geological Survey, Menlo Park, CA 94025)

Multichannel seismic-reflection data across the continental slope between Dixon Entrance to west of Cross Sound define structures associated with the Fairweather fault system. From Dixon Entrance to Chatham Strait, broad folds and faults are associated with the possible extension of the Fairweather fault system along the continental slope. Folding decreases in amplitude to the north. Folds at the base of the slope are young features that may contain deformed sediments. Between Chatham Strait and Sitka, only minor deformation is seen in the [illegible]. [illegible] beneath the continental slope between Sitka and Cross Sound is [illegible]. West of Cross Sound off Fairweather [illegible], strata at the base of the slope are folded. These structures are limited in areal extent, affect [illegible] sediment, and strike almost perpendicular to the [illegible] rather than paralleling the trend of the slope. Interpretation of the data suggests that for at least the last 3 to 5 m.y.: (1) crustal deformation between Dixon Entrance and Cross Sound is probably related to the extension of the Fairweather fault system across the continental slope, rather than to [illegible] between the Pacific and North American plates; (2) no faulting has occurred beneath the slope between Sitka and Cross Sound; (3) west of Cross Sound, there is no evidence for underthrusting of the Pacific plate beneath the continental margin, and the only permissible location for faulting is near the top of the slope; and (4) there is also little evidence for a transition in the vicinity of Cross Sound from transform motion on the Fairweather fault to [illegible] between the continental margin.

SEAWARD EXTENSION OF THE FAIRWEATHER FAULT ON THE SOUTHEASTERN ALASKA SHELF

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George Plafker Menlo Park, CA 94025)
Terry R. Bruns

The Fairweather fault has been mapped for a distance of 300 km across the continental margin south of Icy Point using 1500 km of seismic lines. The seismic data show evidence for two fault traces. The eastern fault trace lines up with Fairweather fault. The western trace lines up with a fault that is inferred, on the basis of structural features, to lie just offshore of the coastline and to extend at least as far north as Lituya Bay. These two traces extend south-southeast across the shelf for about 225 km where they appear to merge on the upper slope just southwest of Sitka. South of this point, the merged fault trace is seaward of the shelf break and extends along the same trend for at least another 75 km. Further southeast, features suggestive of faulting are present on widely spaced multichannel lines near the base of the continental slope. At several places where the shelf faults bifurcate, the minor trace forms an arc and appears to rejoin the major trace. About 23 km southeast of Palma Bay, the Fairweather fault undergoes a major bifurcation, a branch fault trends toward Lisianski Inlet where it may connect with the Peril Strait fault. Some seismic profiles show no surface offset, but the fault is inferred from broken reflectors or abrupt changes in bedding attitudes. Other profiles show well-defined scarps on the sea-floor with relief of 25-43 m. Where such seafloor offsets are well displayed, the sense of movement is northeast side down, consistent with observed displacement onshore along the Fairweather fault during the 1958 Lituya Bay earthquake. The data suggest that these fault traces on the continental margin connect the Fairweather and Queen Charlotte faults.

THE APOTHEOSIS OF WRANGELLIA

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The region enclosing Queen Charlotte Islands, Dixon Entrance, Hecate Strait, Queen Charlotte Sound and Vancouver Island is characterized by distinctive, allochthonous Triassic and Paleozoic rocks known respectively as Wrangellia and the Alexander Terrane. Paleomagnetic studies have shown that each terrane originated far to the south of its present position. Wrangellia is believed to have "docked" with the Alexander Terrane in Early Cretaceous time, after the latter had reached its present position. The locus of coupling extends across Hecate Strait and is expressed as the Rennell Sound and Sandspit - Chatham Strait faults.

During late Tertiary time, as western North America moved westwards over the Anahim hot spot, crustal attenuation, through the development of crustal pervasive normal faults, occurred beneath Queen Charlotte Sound. This resulted in the local disruption of Wrangellia, the extrusion of extensive plateau lavas, and the northward dislocation of the proto Queen Charlotte Islands along the Louscoone Inlet and Rennell Sound Fault Zones.

The reconstructions suggest that the Chatham Strait, Sandspit and Louscoone Inlet Faults belong to one continuous feature extending for more than 1000 km from Alaska to southern British Columbia.

QUEEN CHARLOTTE FAULT ZONE: HEAT FLOW MEASUREMENTS

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Five marine heat flow measurements in the Queen Charlotte trough, 3 marine measurements on the Queen Charlotte fault zone terrace and 11 land borehole measurements at a site near the west coast of the Queen Charlotte Islands indicate a continuous transition over a distance of 50 km from high deep sea heat flow to low continental heat flow. The mean of the deep sea values corrected for sedimentation of 240 mW m^{-2} is somewhat higher than the theoretical value for the 7.5 Ma ocean crust. The low mean heat flow at the land site of about 37 mW m^{-2} is similar to or lower than other values for the coast Insular Belt to the south and east. Numerical models suggest that there is a deep thermal contrast at the seaward edge as well as at the landward edge of the terrace. Thus the crust beneath the terrace is inferred to be different and probably older than that beneath the adjacent deep sea floor.

QUEEN CHARLOTTE FAULT ZONE: MICROEARTHQUAKES FROM A TEMPORARY ARRAY OF LAND STATIONS AND OCEAN BOTTOM SEISMOGRAPHS

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R.M. Ellis (Dept. of Geophysics and Astronomy, University of British Columbia, Vancouver, B.C. V6T 1W5)

A temporary array of land and ocean bottom seismograph stations was used to accurately locate microearthquakes on the Queen Charlotte fault zone which occurs along the continental margin of western Canada. The continental slope has two steep linear sections separated by a 25 km wide irregular terrace at a depth of 2 km. Eleven events were located with magnitudes from 0.5 to 2.0, ten of them beneath the landward of the two steep slopes, some 5 km off the coast of the southern Queen Charlotte Islands. No events were located beneath the seaward and deeper steep slope. The depths of 7 of these events were restrained by the data, and most occurred near 20 km. The earthquake and other geophysical data are consistent with a vertical fault zone although the suggestion of a component of underthrusting of the oceanic crust beneath the islands and a dipping fault zone cannot be excluded. One event was located some 50 km inland of the main zone and probably occurred on the Sandspit fault. The rate of seismicity on the Queen Charlotte fault zone during the period of the survey was similar to that predicted by the recurrence relation for the region from historical data.

REFRACTION STUDIES ACROSS THE SOUTHERN QUEEN CHARLOTTE FAULT ZONE

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R.M. Ellis British Columbia, Vancouver,
R.M. Clowes B.C. V6T 1W5)

In 1979 a University of British Columbia-Pacific Geoscience Centre refraction seismic program was conducted in the southern Queen Charlotte Islands region. The area is of particular interest as there is direct ocean-continent contact along the transform fault zone. Two profiles, one parallel and the other perpendicular to the west coast of the islands were recorded on three ocean bottom seismometers (OBS'S) and five land-based stations from a series of shots along the profiles. Two marine shots to the northeast of the islands, one southeast and a mine blast to the northeast of the region provided additional data. A 16 l. (1000 cu. in.) airgun was used to obtain shorter profiles across the OBS'S. The data is being interpreted by the MOZAIC modified time term technique and by conventional modelling and inverse techniques for profiles. The results of a preliminary first arrival interpretation for the perpendicular profile show an oceanic mantle refraction at a depth of 10 km with a velocity of 8.1km/sec.

GRAVITY MODELLING ACROSS THE QUEEN CHARLOTTE FAULT ZONE

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The gravity anomaly field across the Queen Charlotte Fault zone is characterized by a linear high amplitude anomaly couple (-80 mgal free air, +70 mgal Bouguer) of peak to peak width less than 30 km. The axis of the gravity 'low' occurs over the offshore terrace rather than the Queen Charlotte trough and indicates that the terrace is underlain by a considerable mass deficiency.

Modelling of the anomaly couple shows that the crustal structure of the terrace differs from both the ocean to the west and the Queen Charlotte Islands to the east. Alternatives range between depressed ocean crust overlain by up to 6 km of sediments and crust of intermediate (c. 15 km) thickness overlain by 1-3 km of sediments. Distinction between these alternatives will ultimately depend upon other geophysical and geological evidence.

CONSTRAINTS ON THE RECENT HISTORY OF THE QUEEN CHARLOTTE TRANSFORM BOUNDARY AS PROVIDED BY THE HISTORY OF THE WINONA BASIN

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A compilation of geophysical and geological data in the region of the Winona Basin provides constraints on the nature of the Pacific-America boundary along the southern Queen Charlotte Fault system. Biostratigraphic studies at DSDP site 177 indicate that the crust there is roughly 4-5 Ma in age and that uplift on the Paul Revere Ridge began only within the last 2 Ma. Heat flow indicates that the crust throughout the basin is young and seismic reflection profiles indicate that the asymmetric formation of the basin is tectonically inseparable from the asymmetric uplift of the Paul Revere Ridge. Magnetic anomaly amplitudes in the basin are extremely low, probably because of high crustal temperatures beneath the thick, continuous, thermal blanket of sediment.

The most reasonable model for past spreading geometry is one in which the crust beneath Winona Basin was created at an extended Juan de Fuca/Explorer Ridge which terminated at the continental margin near Brooks Peninsula. Prior to 2 Ma the major Pacific-America transform plate boundary must have extended as far southeast as this junction, and the location of the boundary may have been significantly landward of its present position. If this were the case, the subsequent major change in local plate geometry, exemplified by the formation of the Winona Basin and the migration of the spreading system to the northwest, could have been a response to a blockage in the transform system some distance away.

REGIONAL NEOTECTONIC ANALYSIS OF THE WILLAPA HILLS REGION, SOUTHWESTERN WASHINGTON - PROGRESS REPORT

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The regional neotectonics for the Willapa Hills region in southwestern Washington are currently being evaluated. The basic elements involved in the analysis include an evaluation of the age, relative recurrence and relative amount of displacement on faults; an evaluation of surface and subsurface lineaments; an assessment of possible deformation and uplift of late Cenozoic deposits; construction of a SLAR lineament map; and an evaluation of recent crustal movement studies based on geodetic leveling data. These elements have been evaluated in light of current thinking concerning the plate tectonics of the Pacific Northwest. Preliminary results suggest that the area has undergone a relatively constant, low rate of uplift through most of late Cenozoic time. The active or potentially active faults appear to have low rates of slip characterized by small displacements and long recurrence intervals.

MAGNITUDE OF NEOGENE HORIZONTAL SHORTENING IN THE WESTERN COLUMBIA PLATEAU WASHINGTON-OREGON

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The western Columbia Plateau is deformed by more than 12 narrow, west trending anticlinal uplifts with broad intervening synclinal structural basins. Detailed (1:6,000) and reconnaissance (1:62,500) studies revel that most anticlinal uplifts have extensive thrust faults in the deformed zones. Balanced geological cross-sections, 300 kilometers north-south from near Ellensburg, WA to Madras, OR show a minimum of 15 kilometers of horizontal shortening along the eastern flanks of the Cascade Range. The horizontal shortening decreases to less than 4 kilometers in sections constructed to the east of 120 degree meridian through the Pasco Basin. The horizontal shortening across individual uplifts is as follows:

	W of 120°	120°	E of 120°
Frenchman Hills*	1.5 km	0.5 km	0.5 km
Saddle Mountains*	0.5	1.0	0.5
Manastash Ridge	2.5	1.0	?
Umtanum Ridge	2.0	2.5	<1.5
Selah Ridge	0.5	–	–
Yakima Ridge*	1.0	0.5	1.0
Ahtanum Ridge	1.0	0.5	–
Toppenish Ridge	1.5	1.0	–
Horse Heaven Hills*	1.5	1.0	0.5
Columbia Hills*	1.5	1.0	0.5
Tygh Ridge	1.5	–	–
Total Shortening	15.0 km	9.0 km	4.0 km

The rapid decrease in shortening to the east of the 120 degree meridian must be accounted for by strike-slip movement either parallel or oblique to the structure.

*Includes adjacent structures on strike.

HYDROLOGY

Thurs. Sept. 25. AM.

Lecture Room

Chairman
O. Slaymaker,
Univ. of British Columbia,
Vancouver.

SIMULTANEOUS AND SEQUENTIAL SAMPLING METHODS TO ESTIMATE NUTRIENT FLUX

L.J. Zeman (Water Quality Branch, Pacific and Yukon Region, Inland Water Directorate, Vancouver, V6E 2P1) and Olav Slaymaker (Department of Geography, University of British Columbia, Vancouver, V6T 1W5)

During the period of 1976 to 1979, a long-term monitoring program of nutrient transported by the Okanagan River at Penticton, B.C. was carried out with the objective of determining temporal and spatial variation of nutrient flux into Skaha Lake. To assess the nutrient load variability in this river reach emphasis was placed on precision and accuracy of measurements of nutrient concentrations and estimation of their loads. Principles of precision and accuracy applied to the measurements of nutrient concentrations were achieved by employing simultaneous and sequential sampling methods.

In the application of simultaneous method, an algorithm was developed for calculation of the partial nutrient loads in the individual subsections of the channel, the total cross-sectional loads and their confidence intervals. Precision of load estimates obtained by this method provided a basis for graphical and statistical comparison of load data obtained by sequential sampling method. A test of consistency of load estimate was achieved by comparison of results obtained from simultaneous and sequential methods.

SEDIMENT TRANSPORT EFFICIENCY AS A CRITERION FOR STREAM CHANNEL CROSS-SECTIONAL SHAPE

Michael G. Foley (Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352)

A mathematical model has been developed to investigate the hypothesis that the equilibrium cross-sectional shape of a stream channel results in maximum sediment transport for the given discharge and boundary sediment type. The model treats this hypothesis as an isoperimetric problem in the calculus of variations. A differential equation describing channel shape can be derived if sediment transport rate is expressed in terms of boundary shear stress and the critical tractive shear stress of the boundary sediment. Present sediment transport models restrict this application to bed-load streams.

The resulting differential equations derived using several Duboys-type bed-load transport equations do not appear to have closed-form solutions or tractable boundary-condition behavior. However, a simplified analysis suggests that the width-depth ratio of rectangular channels with optimum bed-load transport varies linearly with discharge at large discharges (depth stays constant), and is a sensitive function of bed-load size and channel slope, in addition to the silt-clay content of the boundary material. This general behavior does not appear to agree with field observations, suggesting that either the mathematical model, the hypothesis, or both are invalid. An independent verification of the model is necessary before validity of the hypothesis can be tested.

Parker (J. Fluid Mech., 1978) has calculated equilibrium channel cross-sectional shapes using a more physically-based model. However, to date, it has not been possible to compare results of the mathematical optimization model with Parker's because of the need to include cross-channel shear stress transfer and suspended sediment transport in an already overly-complex differential equation.

HYDRODYNAMICS OF THE FRASER FORESHORE

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Data collected on both Roberts and Sturgeon banks have been organized to assess the gross hydrodynamic patterns including the interaction of the Fraser distributories with Straits of Georgia flow on the banks.

While potentiometric flow dominates the banks, clockwise gyres form both on Sturgeon and Roberts Bank late on flood tides. The Roberts Bank gyre is centered on Canoe Pass on the foreshore whereas the Sturgeon Bank gyre is centered somewhat offshore of the outer edge of the foreshore.

The gyres have environmental significance both with regard to the Salmon Fishery and with regard to structures on the foreshore including the Roberts Bank superport.

PROGRESS REPORT: INVESTIGATION INTO COLUMBIA RIVER GLACIAL AGE FLOODING AND SEDIMENTATION AT HANFORD, WASHINGTON.

Wallace H. Walters
Richard L. Skaggs (both at Battelle-Northwest, Richland, WA 99352)

This study has two primary objectives: 1) To analyze the magnitudes and sequences of glacial age flooding and sedimentation along the Columbia River from Sentinel Gap to Wallula Gap to gain insight into the hydraulics of both ancient and modern flood episodes and 2) using the initial hydraulic and geomorphic analysis together with groundwater well data to investigate the reasons why drastic differences in hydraulic conductivity occur within the adjacent glaciofluvial flood plain.

A premilinary analysis of the study reach using USGS topographic maps, geologic mapping, and field reconnaissance has been completed. The results indicate several Pleistocene flood channels, shifts in river courses, and scour and deposition areas. The hydraulic model, HEC-6 Sour and Deposition in Rivers and Reservoirs is currently being used to estimate water discharge and sediment transport capacity for the glacial flood channels.

Using available contoured maps of the study reach showing bedrock, water table, and hydraulic conductivity contours coupled with the hydraulic and sediment transport results, an analysis and evaluation of the groundwater system characteristics will be performed. The results are expected to identify possible groundwater pathways and ranges of hydraulic conductivities in areas where well data is scarce or non-existant.

HYDROLOGIC-ECONOMIC LINKAGES IN RECENT PLANNING ANALYSES OF THE COLUMBIA RIVER REGION

R.G. Kraynick
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In the last 4 years, five major studies of water development and allocation in the Columbia River region have been published. Because the conclusions on management policy are of particular interest to water resource professionals, it is particularly disconcerting that the results hinge critically on the proper definition and delineation of some key issues. This paper focuses upon the key issue of hydrologic-economic linkages inherent in each study and finds some striking differences in assumptions, data, and analytical techniques used to substantiate policy recommendations. Such linkages lie at the heart of what are called tradeoff analysis, the means by which decision-makers hope to resolve water allocation dilemmas.

The linkages enable units of discharge and quantities of water diverted to be converted to physical outputs and monetary valuations of output and vice-versa. Only one of five studies, for instance, allows for any interdependencies in quantities of water and levels of physical outputs achieved in irrigation. Significantly different assumptions on the scheduling of developments and the nature of management (of intensity of use and duration of use) for existing facilities (e.g., hydro power) also inhibits comparability. In addition, the means by which total economic impacts of alternative management and allocation strategies are derived differs greatly from one study to the next: three studies employ economic input-output models and two attempt econometric modeling.

With pending federal and state legislation, judicial decisions, and administrative edicts all likely to affect management of the Columbia River, it is concluded that most contemporary efforts to devise frameworks for management should be consistent with one another.

COLUMBIA RIVER WATER WITHDRAWAL STUDY

Jeffrey B. Bradley (Hydrology Section, Portland District, Corps of Engineers)
Robert Flowers (Portland District, Corps of Engineers)

The Columbia River is a complex and heavily utilized resource which in the past appeared to be unlimited. Now it is evident that the system will be unable to continue to completely serve its many diverse uses such as irrigation, flood control, hydropower, navigation, fish migration, and recreation. Diverse, interrelated uses within the basin affect water quality, fish and wildlife habitat, and the social and economic factors influencing the quality of our lives. This paper presents the state of the art of hydrologic modeling for multi-purpose use and showcases a technique developed for the Columbia River Water Withdrawal Environmental Review analyzing effects of additional irrigation in the region.

Baseline conditions, and two hypothetical levels of increased irrigation development were established. A hydrologic model of the Columbia River system, the Hydro System Seasonal Regulation Program (HYSSR), was used to simulate power generation and flood control projects under varying load and flow conditions over an extended time period. This model allowed us to assess our three scenarios as it stays within constraints placed on the system by other water uses, most importantly irrigation.

HYSSR is a model limited to the mainstem Columbia and Snake Rivers which allows us to assess large level irrigation depletions. A future step required in order to best manage water resources is the hydrologic modeling of specific Columbia River tributaries at increased development levels.

PROGRAMMING SATELLITE RAINFALL ESTIMATION

D. V. Ingraham
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A sequence of computer routines has been developed to facilitate the use of a technique (Ingraham, 1980) which enables rainfall to be estimated from GOES satellite images for those types of non-tropical storms commonly occurring over B.C. This technique relates the vertical flux of moisture into the cloud as determined from the water content of the air mass and the divergence of the cloud top as measured from successive satellite images, to the rainfall rate.

The initial computer routine requires the user to identify each storm cell, assign it a unique identification number and to track the cell from one image to the next. In addition, the user is required to digitize the perimeter of the cell temperature contours and to input the various estimation parameters. The contour temperature T is input every half hour, the water content wc and the lapse rate γ_s are input every 6 hours, while the efficiency e is usually fixed for each storm. Using these and the perimeter coordinates the divergence ($\frac{1}{A}\frac{dA}{dt}$) and rainfall for each contour are calculated half-hourly. The movement of the cell is also computed and rainfall is interpolated for those stations lying between contours. The computer routines greatly facilitate the computations. Potential difficulties of completely automating this procedure are also noted.

EFFECT OF SCALE ON COMPLEXITY OF SNOWMELT SYSTEMS

L.N. Braun (Swiss Federal Institute of Technology, Zurich, Switzerland) and Olav Slaymaker (Department of Geography, University of British Columbia, Vancouver, B.C., V6T 1W5)

During the meltseason of 1978, the nature of snow and ice storage, the energy sources and the stream flow response were investigated at a site, a small-scale and a meso-scale watershed in the Coast Mountains of British Columbia. Differences in system internal homogeneity and system response times at each of these scales indicated the usefulness of this empirical classification. It is also demonstrated that different methods of analysis of snowmelt systems are appropriate at the different scales.

MT. ST. HELENS HYDROLOGY

Thurs. Sept. 25. AM.

Lecture Room

Chairman
O. Slaymaker,
Univ. of British Columbia,
Vancouver.

EFFECT OF ASHFALL ON SNOWMELT RATE AT PARADISE, MOUNT RAINIER, WASHINGTON

Bert E. Brown, Physics Department, University of Puget Sound, Tacoma, Wash. 98416

Snowpack data and temperature information in the form of degree-day calculations are analyzed for Paradise, Mount Rainier for the weeks following the May 18 eruption of Mt. St. Helens. The figures are compared with similar computations for the preceding 25 years. The results show that the dark ash layer increased the snowmelt rate by some 40% over what would have been expected from ambient temperatures.

EFFECT OF MOUNT ST. HELENS VOLCANIC ACTIVITY ON THE TURBIDITY OF THE COLUMBIA RIVER PLUME

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H. Curl, Jr.

As part of NOAA's monitoring effort concerning the environmental impact of the recent Mount St. Helens volcanic activity, the Pacific Marine Environmental Laboratory has conducted three cruises (May 29-June 2, July 8-11, and August 24-28, 1980) off the Washington-Oregon coast to measure suspended sediment concentration and distribution in the Columbia River plume. Surface expression of the plume was mapped by continuous shipboard readings of salinity and light transmission; plume thickness was measured at selected stations by vertical CTD/transmissometer casts. Discrete water samples were periodically taken throughout the cruise to calibrate the transmissometer in units of mg/l. Data from the first two cruises (the third to occur subsequent to the abstract date) indicated a typical summer plume development with the salinity and suspended sediment axes running approximately south-southwest from the river mouth. Sharp gradients of both properties were observed north of the river. The actual size of the plume, however, seemed appreciably diminished relative to a normal summer based on the geographic positions of various isohalines. Suspended sediment concentrations in the upper 2m of the plume during May 24-June 2 ranged from >80mg/ℓ ~3km southwest of the river mouth to ~2 mg/ℓ 60 km down the plume axis. Concentrations at comparable distances during July 8-11 had decreased to <15mg/ℓ and <1mg/ℓ. Scatter plots of salinity vs light transmission for both cruises showed a moderate increase in turbidity between oceanic water at 32‰ and plume water at 26‰, a rapid increase between 26‰ and 23‰, and a high and variable turbidity between 23‰ and 20‰. Absolute turbidity levels during July were lower than in May/June at all salinity values.

UTILIZING THE NATIONAL WEATHER SERVICE'S DYNAMIC WAVE MODEL ON THE LOWER COLUMBIA RIVER DURING THE MOUNT SAINT HELENS EVENT

C. E. Orwig (Northwest River Forecast Center, 121 Custom House, Portland, Oregon 97209)

The recent Mount St. Helens eruption produced mudflows which disrupted normal river traffic in the navigation channel of the Columbia River. A concerted effort was made to restore traffic as soon as possible. This entailed primarily dredging operations by the U. S. Army Corps of Engineers and tidal stage forecasts by the Northwest River Forecast Center for the Longview location. With information on predicted dredge depths in the navigation channel and predicted river stages the U. S. Coast Guard was able to optimize the passage of river traffic through the Longview constriction.

This problem was an ideal application for the National Weather Service's Dynamic Wave Model. This implicit routing model was developed by the NWS Hydrologic Research Laboratory in the early 1970's. The model was applied to the Lower Columbia River below Bonneville Dam with good results. This reach of the Columbia River has a very flat slope and flows are affected by tides from the Pacific Ocean. The tidal effect extends as far upstream as the tailwater of Bonneville Dam during periods of low flow. Reversals in discharge during low flow are possible as far upstream as Vancouver, Washington.

In this application tidal fluctuations for the Longview location were made on a daily basis for a three-day period. These forecasts were used directly by the U. S. Coast Guard to compute the maximum draft vessel that could transit the Longview location. The results were very good both in timing and height. Several examples of the dynamic routing results are shown and some of the current limitations are presented.

FORECASTING THE COWLITZ RIVER AFTER THE MOUNT SAINT HELENS ERUPTION

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(Sponsor: Donald W. Kuehl)

Mount St. Helens' eruption devastated an area of 388 square kilometers depositing ash, sediment and debris from the mountain down the North and South Forks of the Toutle River and on down the Cowlitz River into the Columbia River. The depth of sediment in the channels and over the flood plain varies from several hundred feet near Spirit Lake to 10 to 15 feet at the main river forecast point at Castle Rock on the Cowlitz River. There are many agencies currently cooperating in an attempt to repair the damage and minimize the effects of the eruption on the hydrology of the area. The devastation, ash and sediment deposits have changed the river channel capacities and will alter the response of a portion of the Cowlitz Basin to rainfall.

The National Weather Service, through the Northwest River Forecast Center at Portland, Oregon, and the Weather Service Forecast Office at Seattle, Washington, provide river and flood forecast service for this area. To help in this effort an expanded data network will be installed prior to the flood season. The network of 20 precipitation and 27 river stations is a cooperative effort by two federal agencies and two power companies. The National Weather Service portion of the data reporting network is of the "change of status" type.

The Streamflow Synthesis and Reservoir Regulation (SSARR) model will be used to forecast 10 watersheds and the downstream points. Models calibrated on historical conditions will have to be revised to reflect changed watershed response functions and channel routing conditions. Even as winter progresses there will be changes in these conditions. We will be continuously updating the model coefficients as the changes in watershed and channel occur.

VOLCANOLOGY

Thurs. Sept. 25. PM.

Lecture Room

Chairman
J.D. Cocker,
Oregon State Univ.,
Corvallis.

LATERAL VARIATION OF INTERNAL STRUCTURES WITHIN GRANDE RONDE BASALT FLOWS, SOUTH-CENTRAL WASHINGTON

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Recent studies of Grande Ronde Basalt stratigraphy in south-central Washington have allowed us to both trace single flows in surface exposures and correlate certain chemically unique flows between boreholes. One result of this work is a nearly three-dimensional picture of the intraflow structures of portions of two Grande Ronde Basalt flows. Typical intraflow structures (top to bottom) within these flows include: ropy to brecciated flow top; coarsely columnar basalt (upper colonnade); hackly to columnar basalt with relatively small, regular columns (entablature); relatively large, regular columns (lower colonnade); and a glassy basal zone which is either pillowed, vesicular, or highly fractured. One or more of these intraflow structures may be absent or present in multiples. For example, in one flow, the basal pillowed area pinches out entirely. We suggest that the pillowed zones are caused by ephemeral lakes created when the initial lobes of the flow intersected and blocked paleodrainages.

A flow which consists of multiple tiers of entablature and colonnade may change laterally to a single lower colonnade and a uniform entablature. Such tiering of the flows may be related to pulsations which may or may not be periodic. Flows without tiering probably were emplaced as a single mass or with little time between pulses. We suggest that whether tiering occurs or not, is determined by the details of flow emplacement and is influenced by a number of factors including topography and fluid mechanical properties of the magma.

TRACE ELEMENT COMPOSITION OF GRANDE RONDE BASALT PASCO BASIN, SOUTH-CENTRAL WASHINGTON

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G. G. Goles (Department of Geology, University of Oregon, Eugene, Oregon 97403)

Concentrations of 29 minor and trace elements have been measured in >400 samples of Grande Ronde Basalt by neutron activation and X-ray fluorescence analysis. Samples are from deep core holes and surface exposures of Grande Ronde basalt in and around the Pasco Basin. The purpose of these analyses was two-fold: 1) to test their potential as tools for determination of the stratigraphic sequence in support of correlations based on major elements, and 2) refinement of flow-by-flow stratigraphy. Both of these purposes were achieved, although flow-by-flow trace element differences are subtle and are limited to certain horizons. All stratigraphic relationships based on major elements have been confirmed; particularly useful are the trace elements Cr, Zr, Th, Rb, La, and Ce. Cr appears to be the most useful element for distinguishing flows not recognized on the basis of major element composition. We recognize two Cr horizons in the high-Mg Grande Ronde Basalt. Here 2 to 4 flows of lower Cr content (<40 ppm), overlie 3 to 5 flows of higher Cr content (>40 ppm) which in turn overlie lower Cr content (<30 ppm) flows. Within the lower-most low Cr flow, Cr content gradually increases upwards. This gradation may eventually allow further refinement of the stratigraphy.

Trace element ratios suggest that the three Grande Ronde chemical types previously based on major elements either do not have a common source or their trace element concentrations stem from non-igneous processes.

MAJOR AND TRACE ELEMENT STUDIES OF CENTRAL HIGH CASCADES PLATFORM BASALTS

Scott S. Hughes
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(Sponsor: Joshua D. Cocker)

Pleistocene basaltic lavas, generated in response to late Pliocene crustal readjustments, produced coalescent shield volcanoes which comprise an intra-graben basalt platform. Early, open-textured, platform basalts are chemically and mineralogically similar to later Holocene basalts which erupted during the evolution of the High Cascade Range. Major element analyses indicate high alumina contents and consistent MgO/MgO+FeO* values. Chondrite-normalized trace element abundances are characterized by moderately enriched Ba, Sr and LREE. Overall REE patterns (La=35xch., La/Lu=3.18, Sm/Eu=1.04) preclude garnet or plagioclase as partial melt residual phases, but are consistent with residual clinopyroxene. Nearly identical Sc/Hf and HREE patterns indicate a common source for magma generation and a narrow range of melt fractions. Variable Cr/Ni values reflect erratic and high Cr partitioning effects of residual spinel. Trace element modelling presents inconsistencies with single stage melting of a primitive mantle. The data support magma genesis by partial melting of a non-primitive spinel lherzolite source.

Some basaltic units have been notably contaminated during their ascent. Large (up to 5 cm) quartz xenocrysts occur in at least two vent systems. An analysis of lava from one of these areas exhibits higher K, Ba, Sr and LREE and a REE crossover pattern relative to other basalts. Although the LIL elements are enriched in this sample, HREE, Sc, Ni, Co, Cr and Sc/Hf values remain undifferentiated from uncontaminated basalts in agreement with selective addition of crustal constituents.

VAPOR DETONATIONS IN SUPERHEATED FLUIDS*

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P. E. Rosenberg (Department of Geology, Washington State University, Pullman, WA 99164)

A recently developed theory of detonations in phase transforming materials may be applicable to volcanic explosions.[1] If metastable super-heated states can be produced then self-sustaining shock waves, or detonations, are thermodynamically possible. They are analogous to detonations in chemical explosives except that the energy is derived from stored thermal energy rather than chemical energy. Calculations for propane superheated 95 K above the boiling point give values of detonation pressure of about 20 bars and explosive energy of 100 joules/gm--or roughly 2% of the energy of TNT. Preliminary experiments on propane to verify these predictions are encouraging.

*Partially supported by Lawrence Livermore Laboratory and by Los Alamos Scientific Laboratory.

[1] R. L. Fabis, G. R. Fowles, W. Fickett, Phys. Fluids 22, 422 (1979).

LATE PLEISTOCENE SUMMIT CONSTRUCTION AND HOLOCENE FLANK ERUPTIONS OF SOUTH SISTER VOLCANO, OREGON

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(Sponsor: J. D. Cocker)

The South Sister is an isolated silicic center within the predominantly basaltic Central High Cascades. Paleomagnetic polarity data indicate that the entire mountain is less than 700,000 years old, yet the preservation of a summit crater, the symmetric appearance, and the lack of an exposed core suggest a late Pleistocene or Holocene age. Therefore it is important to evaluate the age, style, and frequency of recent eruptions.

The bulk of the South Sister consists of andesite-dacite lavas and scoria of narrow compositional variation (silica 62-66%). Ash flows and ash flows have not been found, which suggests a relatively quiet mode of eruption. A pyroclastic cone containing a blast unconformity caps the andesitic stratovolcano.

Strombolian eruptions during the latest Pleistocene or early Holocene covered the entire summit of the andesite-dacite volcano with basaltic andesite cinders, bombs, spatter, and thin lavas. A crater, 400 m wide, is still preserved but flank lavas and ejecta have been dissected by Holocene glaciers.

During a brief episode (2300-1900 yrs. BP) a series of rhyodacite domes was extruded from flank vents. These produced pumice ramparts near the vents and thin widespread blankets of pumiceous ash. Ejecta from the largest dome (2300 yrs.) are found on the uppermost summit flow. Pleistocene rhyodacite domes, flows, and ash are also characteristic of this area.

Thus the latest activity has been restricted to the flanks, involved small volumes of silicic magma, and was of short duration. Late Pleistocene or early Holocene eruptions of more mafic magma were the final products of the summit vent. Therefore, eruption periodicity is probably best measured in thousands of years.

RATES OF ERUPTION AND VOLCANIC HAZARDS IN THE WASHINGTON CASCADES

BEGET, James E., (Department of Geological Sciences University of Washington, Seattle WA 98195)

Volcanic hazards assessments of dormant volcanoes in the Cascades have relied on determinations of eruption histories. Complimentary studies of longterm rates of eruption for these volcanoes may suggest which eruptive centers are most likely to undergo large pyroclastic eruptions during possible future eruptive events. Initial estimates of rates of eruption, based on published and unpublished data, were made for Mount St. Helens, Mount Rainier, Mount Baker and Glacier Peak. Mount St. Helens, which has a recurrence interval of eruption of approximately 100 years, has an estimated eruption rate of $0.2 \times 10^{-2} km^3 yr^{-1}$ over the last 4000 years. Glacier Peak, Mount Rainier and Mount Baker, each with much lower recurrence intervals of eruption, have estimated rates of eruption of $0.1 \times 10^{-4} km^3 yr^{-1}$, $0.6 \times 10^{-4} km^3 yr^{-1}$ and $0.6 \times 10^{-4} km^3 yr^{-1}$ respectively. This suggests that Glacier Peak is more likely to undergo large pyroclastic eruptions in the future than either Mount Baker or Mount Rainier, but less likely than Mount St. Helens. Magma production rates at each volcano must be somewhat larger than the rates of eruption, as some magma is lost to intrusions. The averaged rate of eruption over the entire Washington Cascades is estimated to be $0.8 \times 10^{-5} km^3 yr^{-1} km^{-1}$. This is the same order of magnitude as previous estimates of eruptions rates for the entire Cascade system and Japanese arc system during the last 20-25 million years (McBirney, 1978; Sugimura and others, 1963).

ELECTROMAGNETIC INDUCTION

Fri. Sept. 26. AM.

Auditorium

Chairman

H.W. Dosso,
Univ. of Victoria,
Victoria.

ELECTROMAGNETIC INDUCTION IN THE BRITISH ISLES REGION

Nienaber, W.
Dosso, H.W. (both at: Department of Physics, University of Victoria, Victoria, B.C. Canada)

A scaled laboratory analogue model is used to study the Geomagnetic coast-effect over the British Isles region. The results for various model frequencies simulating variations with periods in the range of 20 min to 3 hrs, indicate that at the longer periods the anomalous fields are associated with induction in the deep ocean. At shorter periods the induction arrows appear to respond to channelling of induced telluric current in the shallow seas and narrow channels. As well, contours of the vertical magnetic field indicate that, due to the shape of the coastlines, the Eskdalemuir region forms a likely conductive path for leakage currents between the shallow North and Irish Seas.

ELECTROMAGNETIC INDUCTION FOR AN ANALOGUE MODEL OF QUEEN CHARLOTTE ISLANDS REGION

E. Chan
H.W. Dosso (both at: Department of Physics, University of Victoria, B.C. Canada)
L.K. Law (Pacific Geoscience Centre, Victoria, B.C. Canada)

The behaviour of time-varying electromagnetic fields over the Queen Charlotte Islands region is investigated using a scaled analogue model. The model source frequencies simulate periods of 4 minutes, 40 minutes and 2 hours in the geophysical scale. Contour plots for the in-phase and quadrature components of the field components are presented. The effects of the island and mainland coastlines and the shallow ocean channel are discussed.

A FIELD STATION STUDY OF THE COAST EFFECT IN AN ARCTIC BAY

G.J. Heard
H.W. Dosso, W.Nienaber (all at: The Department of Physics, University of Victoria, Victoria, B.C., Canada)
J.E. Lokken, J.G. Farmer, C. Gibb (all at: Defense Research Establishment Pacific, Esquimalt, B.C., Canada)

A field expedition to Assistance Bay was carried out in the spring of 1980. The purpose of the experiment was to gain information on the behaviour of the coast effect in a bay structure at frequencies in the ELF band.

The magnetic field components were recorded at six sea-ice field stations and at two land based field stations spaced along a line running north-south through the bay. The horizontal components of the magnetic field were also recorded at a ninth station located a short distance west of this array. In addition, the horizontal components of the electric field were recorded at two of the sea-ice field stations.

The data obtained from this experiment will eventually be compared to data obtained from a previous expedition to Assistance Bay and to data obtained from an electromagnetic analogue model study of the Assistance Bay region.

ELECTRICAL CONDUCTIVITY BENEATH HAWAII AND TUCSON

J. C. Larsen (PMEL/ERL/NOAA, 3711 15th Ave., N.E., Seattle, WA 98105)

Electromagnetic response curves (0.1 to 8.0 cpd) have been computed for two sites in Hawaii (3 years duration) and Tuscon (11 years duration). Relative error in the response is less than 1%. The response curves can be interpreted by a nonhomogeneous surface layer situated above an earth having uniform conducting layers. The model misfit is about 3%. The conductivity profiles show the usual steep rise in conductivity from 0.01 s/m to 1.0 s/m at 500 km depth.

GEOMAGNETIC INDUCTION DATA FROM MT. ST. HELENS

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D.R. Auld
L.K. Law (both at: Pacific Geoscience Centre, P.O. Box 6000, Sidney, B.C., Canada, V8L 4B2)

We have analyzed 3-component magnetometer data from 4 stations located in various directions between 2.5 and 10 km from the summit of Mt. St. Helens. The stations ran during the period March 26 to May 17, 1980. The cross-correlation between the vertical and the two horizontal field components can be represented as the "induction vector". At all four stations, this vector points about S 55 E at periods longer than 100 seconds. This direction agrees with other regional stations. At periods shorter than 100 seconds, the vector swings toward the mountain. This frequency dependent effect indicates an electrical conductivity contrast in the immediate vicinity of the mountain.

MAGNETOTELLURIC STUDY OF MT. ST. HELENS

A. Schultz (Geophysics Program, AK-50 University of Washington, Seattle, WA 98195)
J. Booker (Geophysics Program, AK-50 University of Washington, Seattle, WA 98195)

A magnetotelluric site was established at Timberline on Mt. St. Helens, Washington. The site was occupied from mid-April through early May, 1980.

Insights into the electrical conductivity structure beneath the volcano will be discussed.

A CLOSER LOOK AT THE CASCADE GEOMAGNETIC ANOMALY

E. Gerald Hensel (Geophysics Program, AK-50, University of Washington, Seattle, WA 98195)
John R. Booker (Geophysics Program, AK-50, University of Washington, Seattle, WA 98195)

Using geomagnetic depth sounding we have delineated an anomalous current in the Cascade Range, Washington. We used three component fluxgate magnetometers at twenty-eight sites between the Columbia River and the Skykomish River. The data suggest an elongated, north-south striking anomalous current at a period of approximately ten seconds. At the Columbia River the current is not localized. Between the latitude of Mt. St. Helens and Mt. Rainier the current flows approximately N 30° W, five to ten km west of a line between Mt. Rainier and Mt. Adams. North of the Greenwater River the current turns west and appears to enter Puget Sound. There is no evidence of the current north of Seattle. Modeling the current as a line current, we calculate a depth of less than fifteen km, indicating that it is associated with a conductive heterogeneity in the upper crust. This conductivity contrast may be associated with Recent Cascade volcanism, or it may mark the boundaries of older crustal provinces in this region.

MT. ST. HELENS I

Fri. Sept. 26. AM.

Auditorium

Chairman
R.S. Crosson,
Univ. of Washington,
Seattle.

SEISMICITY PRECEDING THE MAY 18 ERUPTION OF MT. ST. HELENS

Linda Noson
Steve Malone (both at Geophysics Program, Univ. of Wash, Seattle, WA 98195)
Elliot Endo
Craig Weaver (both with U.S. Geological Survey, working at Univ. of Wash)

On March 20, 1980 an earthquake sequence unlike any other ever recorded in the Pacific Northwest began with a single magnitude 4 earthquake beneath Mt St. Helens. A week after this initial earthquake, ash and steam eruptions began from the summit crater on Mt. St Helens. The eruption on March 27 was preceded by what was identified as an eruption swarm that reached its peak on March 25, when during one eight hour period, 24 magnitude 4 earthquakes occurred beneath the volcano. The activity declined in number of events after that, though some of the larger events occurred near the end of the sequence. The rate of activity fluctuated on a day to day basis from 20 to 50 magnitude 3 or greater earthquakes per day. From March 20 to May 18 the University of Washington's on-line computer system recorded over 10,000 events. Of this number 750 events with magnitudes over 3.2 have been located. Using a preliminary crustal model, events were located at depths of less than 5 km beneath a 5 x 5 km region N and NW of the summit. The number of large magnitude events and the concentration of epicenters beneath the region of deformation probably represent the injection of magma into a shallow reservoir. There were no unusual changes in the seismic activity in the hours preceding the cataclysmic eruption of May 18.

SEISMIC DETAILS OF THE MAY 18, 1980 CATACLYSMIC ERUPTION OF MOUNT ST. HELENS

Steve Malone (Geophysics Program, Univ. of Wash., Seattle, WA 98195)
Craig Weaver
Elliot Endo (both U.S. Geological Survey, working at Univ of Wash.)

At 08:32:11 PDT on May 18, 1980 an earthquake with local magnitude of 5.1 occurred at 46° 12.5' North, 122° 11.0' West and a depth of 0.3±0.6 km below sea level (1.6±0.5 km due north of the summit of Mount St. Helens). From eye witness accounts, within 5 ±5 sec. of this earthquake being felt, a massive avalanche off the north side of the mountain began. An area roughly 1200 m wide by 2000 m long extending from the north crater rim down to just above the Sugar Bowl was involved in this slide. Assuming the slide was accelerated by gravity alone and the friction on its basal surface is negligable it would have attained a velocity of about 100 m/sec 18 seconds after beginning and would have cleared the upper portion of the mountain.

After the removal of this rock mass from the side of the volcano the reduced lithostatic pressure caused the hot water saturating the rocks below to boil explosively. From these observations we estimate the major lateral explosion began from 20 to 30 seconds after the earthquake origin time. At 77.2 seconds after the earthquake origin time the station SOS (located 8.1 km NNE of the summit) went dead presumably from being destroyed by the blast cloud. This implies an average blast cloud velocity of from about 100 to 110 m/sec (360 to 395 km/hour). The seismic station DOG located on the Dogs Head lost telemetry due to radio interference from the eruption cloud. The time of its destruction as well as 3 other stations north of the mountain is not known.

Examination of seismograph records from stations greater than 150 km indicate a second earthquake of roughly the same size occured about 110 seconds after the first. Strong signals were recorded for an additional 10 minutes until 0844. For the following 3 hours the seismic activity was relatively quiet, only about 1 small earthquake (Mag < 1.5) per minute. At 1140 the seismic activity gradually increased. By 1330 discriminating individual earthquakes became impossible due to the large number of events and strong harmonic tremor. The activity peaked around 1540 and then declined to moderate levels by 1730. Harmonic tremor continued at fluctuating levels until June 6, 1980.

PREDICTING MT. ST. HELENS ERUPTIONS

Craig Weaver
Elliot Endo (U.S. Geological Survey, working at Univ. of Wash.)
Steve Malone
Linda Noson (Geophysics Program, Univ. of Wash., Seattle, WA 98195)

Two months of intense earthquake activity preceded the cataclysmic eruption of May 18, 1980. There was no unusual seismic activity preceding this eruption on a time scale of hours to days. There have been four subsequent major eruptions which have had recognizable seismic precursors.

The first of these on May 25 occurred at 0212 PDT after a three hour hiatus in the harmonic tremor amplitude. The tremor had been increasing over the previous day and a half. This change in tremor was not recognized as an eruption precursor at the time mostly because the tremor level had been quite variable for the previous week.

On June 12 increasing harmonic tremor was observed 9 hours before the eruption which had its major pulse at 2111 PDT, again after a tremor hiatus of one hour.

On July 22 there was no harmonic tremor preceding the major outburst at 1714 PDT but an unusual earthquake sequence with increasing numbers of shallow events was recognized eight hours earlier. This sequence began at about 0830 that morning and continued at an average rate of one small (Magnitude < 2) earthquake per hour until early afternoon. By 1400 the rate was up to about 8 events per hour and in the hours preceding the eruption there were over 20 events.

On August 7 again harmonic tremor was recognized as a precursor starting four and a half hours before the 1630 PDT eruption. In this instance there was no quiet period before the eruption began. Seismic precursors have been observed and reported to others at least 4 hours prior to the last three eruptions.

EARTHQUAKES AND ASH ERUPTIONS AT MT. ST. HELENS

Anthony Qamar (Geology Dept., University of Montana, Missoula, MT 59812)
William St. Lawrence (Cold Regions Engineering and Research Lab., Hanover, NH)
Joanne Moore
George Zandvick (both at Geology Dept., University of Montana)

Monitoring of Mount St. Helens during the first week of activity (March/April, 1980) indicates little temporal correlation between earthquakes and ash eruptions. The seismic signals exhibit much lower frequencies than those of normal tectonic earthquakes and, as a result, even the larger volcanic earthquakes were seldom felt. The unusual signals must be strongly affected by the presence of magma nearby.

The recurrence rate (vs. magnitude) of earthquakes prior to the May 18 eruption exhibits a particularly well documented case of slope change (b value) at high magnitudes. In this case it implied a limited source region that could give rise to earthquakes no larger than magnitude 5.

PRELIMINARY CALCULATIONS OF MT. ST. HELENS b-VALUES

S. McNutt (Dept. Geol. Sci. and Lamont-Doherty Geol. Obs. of Columbia Univ., Palisades, NY 10964, in cooperation with the Geophysics Dept., Univ. of Washington, Seattle, WA, 98195)

Amplitude b-values were calculated for subsets of the Mt. St. Helens earthquake sequence for the time period March 20 to May 18, 1980. The first calculation was made using data from station SHW, located 6.5 km west of the summit of Mt. St. Helens. All other calculations were made using station CPW, located 100 km northwest of the volcano. Maximum peak to peak amplitudes were measured to the nearest 1/2 mm on paper helicorder records.

Two distinct event types were recorded on station CPW: high frequency events (> 5 Hz) with P to S amplitude ratio of approximately 1:4, and low frequency events (~ 1.4 Hz) with P to S amplitude ratio of approximately 1:2. Calculations of b-values were made separately for each event type.

A b-value of approximately .6 was found for the initial earthquake sequence from March 21-24 as recorded at SHW. This value is quite low and is characteristic of tectonic rather than volcanic processes. Plots of b-values for later data sets from CPW show changes in slope for different time periods. Each plot shows one or more breaks in slope, indicating that more than one physical mechanism is acting. Each plot suggests the coexistence of a characteristic tectonic and volcanic b-value. B-values for high frequency events range from .4 to 2.4, while those for low frequency events range from .4 to 4.0.

REFRACTION STUDIES OF THE MT. ST. HELENS REGION

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In May 1980 the University of Washington in cooperation with the U.S.G.S started seismic refraction studies in the Mount St. Helens region. Two sources were used: Quarry blasts at a coal mine near Centralia, Wa., 80 km to the northwest of Mt.St. Helens, and quarry blasts at an Army Corps of Engineers flood control project near Camp Baker, 25 km to the northwest of the cone. Aproximately twenty sites have been occupied, although not every site has recovered data from both sources.

Analysis of the unreversed line from the Centralia coal mine indicates a surface layer with a p-wave velocity of 5.0 km/sec, a 5.E km/sec refractor at 2.5 km depth, a 6.4 km/sec refractor at 4.8 km depth, and a 6.7 km/sec refractor at 13 km depth. The 6.7 km/sec arrivals are observed as far away as 180 km from the source, indicating that the depth to the mantle in this region must be at least 30 km.

LONG TERM GRAVITY CHANGES AT MT. ST. HELENS, WASHINGTON

Albert A. Eggers
Z. F. Danes (both at University of Puget Sound, Tacoma, WA 98416)

Repeated occupation of gravity monitoring stations at Timberline, along the Timberline to Spirit Lake Road, at East Dome, and Windy Pass between 3/29/80 and 5/13/80 indicate no meaningful changes in gravity prior to the 5/18/80 eruption. During this period relative gravity increased at Timberline by approximately 70 µgal relative to a base station on Highway 504,12 km west of Spirit Lake. Data from the other stations is inconclusive. The limit of detectability is approximately 50 µgal. Reoccupation of the East Dome and Windy Pass stations on 7/29/80 show respective increases of approximately 300 and 800 µgal relative to Thompson Pass base station subsequent to the May 18 eruption. Several stations used for gravity mapping in 1979 on the south slopes of Mount St. Helens were reoccupied in July and August 1980. Preliminary results indicate increases and decreases in gravity of up to a few 100 µgal at the mapping stations. Post eruption gravity changes are probably caused primarily by the terrain effect of the May 18, 1980 crater.

APPARENT SHORT TERM GRAVITY CHANGES AT MOUNT ST. HELENS, WASHINGTON

Albert A. Eggers
Z. F. Danes (both at University of Puget Sound, Tacoma, WA 98416)

Continuous optical reading of two to four La Coste-Romberg gravity meters for periods of several hours at Timberline on April 1, 3, 4, 5, 6, 7, 12 and 13; at East Dome on April 12 indicated apparent gravity changes of at least a few 10's of µgal with a duration of a few minutes associated with eruptive and seismic events at Mount St. Helens. In some, but not all, instances the apparent gravity changes preceded seismic and eruptive events. The apparent gravity changes were associated with tilt detected by gravity meter level bubbles, and tilt measured using a precision level. On April 26 and 27, 1980, using recording gravity meters (D-4 and G-426) we detected apparent gravity changes of 20 to 30 µgal one to two minutes before seismic events, and of more than 200 µgal during and after seismic events. In the laboratory we found we could simulate the apparent gravity changes by inducing instantaneous tilts of 10's of µ radians, and by instantaneous changes in dial settings of 10's of µgal. Our tentative interpretation is that the precursory part of the apparent gravity changes were caused by short term inflation prior to seismic and explosive events.

TILT MEASUREMENTS NEAR MOUNT ST. HELENS

A.G. Johnson (Earth Sciences Department, Portland State University, Portland, OR 97207)

Two Kinemetric bubble tilt meters were installed in June and July near Mt. St. Helens to assist in observation of tilt associated with the volcanic activity. Three sites have been occupied. Tilt site #1, 11km SW of the mountain was overprinted extensively by temperature effects, and moved in early August to a site 4km SE of the summit near June Lake. The tilt from site #2 NE of Ape Caves, 8km SW of the summit should steady tilt to the south of .02 µRAD/day. The east-west component shows some temperature affects and some earth tidal signal.

A brief segment of site #3 indicates clearly earth tidal amlitudes of approximately .03µR peak to peak amplitude and tilt to the north of .05 µRAD/day.

The two sites occupied clearly show the tilt field is not a simple uplift of the vectors are not pointed directly away from the mountain. Some site specific tilt, settling, or other influence could be disturbing the readings or the tidal

MT. ST. HELENS II

Fri. Sept. 26. PM.

Auditorium

Chairman
A.G. Johnson,
Portland State Univ.,
Portland.

AERIAL INFRARED MAPPING OF THERMAL ACTIVITY AT CASCADE RANGE VOLCANOES

Jules D. Friedman, U.S. Geological Survey, Denver, CO
David Frank, U.S. Geological Survey, Seattle, WA

Analysis of aerial infrared images is the primary method used to construct detailed thermal-anomaly maps for the purpose of monitoring the heat balance of the ground surface at dormant volcanoes. USGS infrared coverage of Cascade Range volcanoes began in the mid-1960's, concomitantly with surveys of the Owens Valley, California volcanic region, using optical-mechanical line scanners that generate continuous-strip analog-mode thermal images. Our work in the Cascade Range, initiated in 1970, expanded the program of intermittent aerial infrared surveys to all of the more thermally active volcanoes and added ground investigations and telemetered surface and shallow-depth temperature monitoring at selected sites. By 1973, aerial infrared surveys had been made at nine stratovolcanoes of the Cascade Range. In recent years, several research groups in addition to the Geological Survey have conducted infrared investigations and the complement of available instrumentation has expanded to include aerial- and ground-based thermographic video-display systems as well as calibrated multispectral digital scanners.

The present knowledge of thermal patterns as mapped by infrared techniques permits the following classification of Cascade volcanoes on the basis of their thermal activity:

Repose-Period Level of Thermal Activity	Example*
Major (>5 MW volcanogenic flux)	B, R, R, SS, LVA
Minor (<5 MW volcanogenic flux)	SH (pre-1980), L, S
Minor ? (suspected on basis of infrared survey, but not field checked)	G?, A?, CL?
Structural Control of Thermal Activity	**Example***
Central Crater	B, R, H, SH
Dome	SH, H, G?, S, L
Flank Vent	B
Flank structure unrelated to recognized dome, crater, or other vent	R, B, L, A?, G?

*B - Mt. Baker, G - Glacier Peak, R - Mt. Rainier, A - Mt. Adams, SH - St. Helens, H - Mt. Hood, CL - Crater Lake, S - Mt. Shasta, L - Lassen Peak, LVR - Lassen Volcanic Region.

NW- AND NE-TRENDING FRACTURE SYSTEM AT MT. ST. HELENS VOLCANO, WASHINGTON

Robert S. Yeats (Department of Geology, Oregon State University, Corvallis, 97331)
Charles L. Rosenfeld (Department of Geography, Oregon State University, Corvallis, 97331)

Several features of the 1980 eruption are controlled by sets of fractures trending NW and NE. The graben that formed March 27 extended NW and NE from the summit and influenced the location of the southern boundary of the great landslide of May 18. Subsequent fracture study was aided by imagery acquired by Oregon National Guard Mohawk aircraft using X-band (3 cm wavelength) Side-Looking Airborne Radar (SLAR) and 8-14 µm (low temperature) and 2-4.5 µm (high temperature) thermal infrared (IR) scanners. A radar image acquired May 28 shows a fracture extending SW from the amphitheater. Low-temperature IR imagery of the amphitheater acquired July 15 shows that the dome was cut by annular and radial fractures superimposed on a SE-trending fracture set. A pronounced SE-trending fracture set was found E, NE, and SE of the dome. At least one of these fractures controlled fumaroles on the SE wall of the amphitheater. SSW of the dome, the source area of a pumice flow that occurred June 12 was cut by a SW-trending fracture set. Moving target SLAR imagery taken during the July 22 eruption showed three eruptive centers, one located over the dome and elongated NW-SE, and the others located to the S and SE at the base of the crater wall. The fracture system may reflect orthogonal joints or it may reflect a conjugate fault system.

COMPARISON OF HYPOTHETICAL AND ACTUAL LAHAR IMPACTS ON PUBLIC SERVICE DELIVERY SYSTEMS

Janet H. Cullen Tanaka (J. H. Cullen & Assoc., Olympia, WA [illegible])

The occurrence of a major eruption, attended by a large lahar affecting a mixed rural and developed area, provided a unique opportunity to validate the conclusions of the previous study of mudflow impact on public service delivery systems (Cullen, 1977).

Preliminary data collection from media, published and draft scientific data, agency statistics, interviews, and on-site damage assessments, was begun immediately following the May 18 eruption and lahar.

Allowing for the relative sizes of the events and the differences in population density, there is good correspondence between the impacts of the Rainier "design event" and the St. Helens event, especially in:

(1)Characteristics of the lahars;
(2)Hydrologic division of the river system into "reaches" and corresponding impacts on the channel, banks, and surrounding area, including manmade structures,
(3)Degree and kind of socioeconomic disruption;
(4)Psychological impacts on survivors.

Dissimilarity was present in the speed of eruption onset and development, resulting in a large number of fatalities.

This study will be completed using the methodology of the Rainier/Puyallup study, and final results used to modify and amend the earlier paper for use by recipients of the previous planning report.

PRELIMINARY CHEMICAL ANALYSIS OF THERMAL WATERS AT MOUNT ST. HELENS, WASHINGTON

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The May 18, 1980 eruption of Mt. St. Helens, Washington, filled the upper North Fork Toutle River valley and Spirit Lake with as much as 60 m of debris. Deposits from (1) an avalanche consisting of hot and cold rock debris and ice blocks, (2) a hot "directed blast", and (3) subsequent pyroclastic flows blanket more than 100 km² of devastated area to the north and northwest of the volcano. Interactions between the hot deposits and shallow ground water produced ephemeral phreatic eruptions, and thermal ponds and streams. Preliminary analyses of warm waters from about 20 sites, including Spirit Lake, show that 2-3 weeks after the eruption, waters were slightly acidic and rich in either calcium bicarbonate or sulfate. Concentrations of total dissolved solids exceeded 1000 mg/L in some samples. Spirit Lake and many of the thermal ponds contained high levels of dissolved manganese (800-5000 µg/L), iron (200-3600 µg/L), and boron (200-800 µg/L), and lesser amounts of other trace metals. The chemistry of these thermal waters is generally consistent with the dissolution of plagioclase, ferromagnesian minerals, and glass, but sulfate, fluoride, and other ions were probably derived from surface exchange sites in the pyroclastic material or from hydrothermally altered clasts in the avalanche deposit. In early June, dissolved-solids levels measured about 0.2 km downstream from the avalanche deposit were somewhat higher than concentrations noted before the eruption. However, concentrations were much lower than those in the highly mineralized thermal waters, suggesting minimal contribution from thermal waters to flow in the North Fork Toutle River at that time.

REMANENT MAGNETIZATION OF MOUNT ST. HELENS ASH OF 18 MAY 1980--A PRELIMINARY REPORT

William K. Steele (Department of Geology, Eastern Washington University, Cheney, WA 99004)

Measurement of detrital remanent magnetization (DRM) in specimens of ash collected from 12 sites in eastern Washington shows that the ash possesses a strong, stable remanence approximately aligned with the local geomagnetic field. The sites are geographically widespread and represent a variety of depositional environments.

Of five sites with ash deposited subaerially, three have mean DRM directions indistinguishable from the geomagnetic field at the 95% confidence level, and the remaining two sites have 95% confidence cones barely excluding the local field direction. At four of the subaerial locations, the ash had experienced rain subsequent to the original deposition, while at the fifth, ash had been deposited under a bridge by strong winds. DRM at this protected site is not significantly different from the local field, indicating that alignment of the magnetic grains can occur in the absence of moisture.

The remaining seven sites represent subaqueous deposition in low to moderate energy systems: streams, intermittent streams, and gullies. All these fluvial sites have DRM statistically different from the local field, and most exhibit large inclination error and/or current-rotation error. Unless nonchemical postdepositional processes improve alignment of DRM with the geomagnetic field, serious mistakes could result from attempts to correlate ancient ashes using DRM acquired in subaqueous environments.

SULFUR AND HALOGEN COMPOUNDS IN THE MT. ST. HELENS ERUPTIONS

A. L. Lazrus (National Center for Atmospheric Research, Boulder, Colorado 80307)

Three stratospheric flights were made through the eruption plumes of Mt. St. Helens in May 1980. Sulfate, chloride and fluoride and particles were measured. Hydrogen chloride, hydrogen fluoride and nitric acid vapors were also measured. These results will be compared with similar observations from several Central American volcanoes and their implications for stratospheric chemistry discussed.

CLAY MINERALOGY OF AIR-FALL, PYROCLASTIC-FLOW, AND RELATED DEPOSITS FROM THE 1980 ERUPTIONS OF MOUNT ST. HELENS, WASHINGTON

David R. Pevear (Department of Geology, Western Washington University, Bellingham, Wash. 98225
David P. Dethier
David Frank (both at USGS, Seattle, Wash. 98105

Trioctahedral smectite is the principal clay mineral noted in X-ray diffraction studies of the <2 µm fraction in about 70 samples of the material erupted by Mt. St. Helens from March through June 1980. Mica accompanies smectite in air fall and pyroclastic flows erupted after midday on May 18 but is absent in material erupted earlier. Cristobalite, smectite/chlorite intergrade, and chlorite may be present in minor amounts. The smectite probably originated from pervasive pre-1980 low-temperature alteration of mafic minerals in the upper part of the volcano. The appearance of mica corresponds to an increasing magmatic component in the May 18 eruption and implies that the mica was probably formed by higher temperature thermal alteration. Alternatively, the mica may occur as phenocrysts in pumice, although it has not been noted as a component of the silt fraction or in thin-section studies. Although preliminary analyses indicate that minor amounts of smectite/chlorite intergrade and chlorite may be forming, the deposits remained largely unaltered by early June after 20 days of contact with warm (>25°C) slightly acidic waters.

TRACE ELEMENT ANALYSES OF MOUNT ST. HELENS PUMICE AND SEPARATED PHASES

Scott S. Hughes (Dept. of Geology, Oregon State University, Corvallis, OR 97331)
(Sponsor: Joshua D. Cooker)

Trace element abundances of May 18 pumice and separated mineral and glass phases have been analyzed by sequential INAA as an empirical study of partitioning effects. Dacite pumice analyses show moderate to strong enrichments in Ba, Sr, Rb, LREE, Hf, Ta and Th relative to chondrites and an overall decrease in C-N abundances with decreasing ionic radii. Moderately fractionated REE patterns (La/Lu= 5.8 to 6.8, La/Sm=2.3, La=30.8 to 33.3 x ch.) indicate no Eu anomalies and low total REE abundances.

Analyses of pumice mineral separates exhibit reasonable trace element patterns. A comparison of mineral analyses to the pumice glass analysis indicates higher (10x) empirical partition coefficients for orthopyroxene (hyp.) and magnetite than reported experimental values. Plagioclase partition coefficients show little or no increase over published values. Magnetite and orthopyroxene also exhibit negative Ce anomalies compared to the glass and both have non-detectable Cs and low Rb values. Magnetite, however, has anomalously high Sr with respect to glass and high Rb compared to orthopyroxene. Qualitatively, the data support volatile influence on oxidation state and high silica/alkali content of magma as essential factors which control some trace element partitioning.

PHOTOGRAPHIC DOCUMENTATION OF THE ERUPTION OF MT. ST. HELENS, 8:32AM, MAY 18, 1980

Keith Ronnholm (Geophysics Program AK-50, University of Washington, Seattle, WA., 98195)

Sequential photographs of the initial eruption of Mt. St. Helens on May 18, 1980 have been analyzed to yield data on the landslide velocity, the ash cloud expansion velocity and the rise rate of the cloud. Measurements of debris vapor trails yield ejecta velocities. The author will present an eyewitness account of the blast as viewed from 16 km. northeast of the summit.

OCEANOGRAPHY

Fri. Sept. 26. AM.

Lecture Room

Chairman
D.P. Krauel,
Royal Roads Military College,
Victoria.

THE WORLD METEOROLOGICAL ORGANIZATION'S STORM SURGE RESEARCH PROGRAM FOR BANGLADESH

T.S. Murty
R.F. Henry (Both at: Institute of Ocean Sciences, Sidney, B.C., Canada, V8L 4B2)

Large amplitude storm surges have killed millions of people over the last two centuries in Bangladesh and caused great devastation. More than 40% of the deaths due to storm surges on the globe occur in Bangladesh and this proportion is gradually increasing with time. During the period 1875 to 1974, thirty two major storm surges occurred which affected the Coast of Bangladesh. At the request of the World Meteorological Organization (W.M.O.) the Institute of Ocean Sciences (IOS) has undertaken a comprehensive study of this problem with the aim of developing a capability for storm surge prediction for the Coast of Bangladesh. The statistical-empirical models and finite-element numerical models that are the key elements of this research program will be briefly discussed and some initial results will be presented.

TSUNAMI POTENTIAL IN THE YAKATAGA GAP

M.E. Blackford (NWS/Alaska Tsunami Warning Center, Palmer, Alaska 99645)
G.C. Carte
R.A. Eppley (both at ATWC, Palmer, AK 99645)

The potential for a great earthquake in the vicinity of Cape Yakataga on the north coast of the Gulf of Alaska is well recognized in terms of seismic gap theory. The tsunami potential from such an event is dependent upon the direction and extent of faulting associated directly with the earthquake and upon indirect effects of strong ground shaking such as rockfalls, submarine slumps, massive glacial calving, and seiches. A number of northerly to northwesterly dipping imbricate faults within the Yakataga gap appear to be a surficial manifestation of the transition from the subduction-type plate boundary of the Aleutian trench to the transform-type boundary along the Queen Charlotte-Fairweather fault system. Dislocations within the offshore portions of this zone could give rise to a tsunami affecting coastal communities of northern Kodiak Island and Prince William Sound to the northwest and communities in southeastern Alaska and British Columbia to the southeast. Local tsunamis due to the indirect effects of ground shaking are likely to occur in the various bays and fjords near the epicentral area. Increased use of the waterways and harbors in the Gulf of Alaska vicinity and the population growth in the area in general have heightened the danger to life and property from tsunamis. A continuous program to keep communities aware of, and prepared for the local tsunami hazard is very important and the timely utilization of advances in tsunami detection and communications is also necessary for tsunami warning systems to play a role in earthquake hazard reductions.

ON COASTAL FLOW IN THE NORTHEAST GULF OF ALASKA NEAR YAKUTAT

Cathleen Wright
J.D. Schumacher
R.K. Reed (all at: NOAA, Pacific Marine Environmental Laboratory, Seattle, WA 98105)

Is there evidence of a baroclinic coastal flow regime in the northeast Gulf of Alaska similar to the Kenai Current in the northwest Gulf?

Recent data from CTD casts in a region of the northeast Gulf of Alaska near Yakutat provided the basis for seasonal maps of geopotential topography (0/90 db) and salinity at 10 m. Relief across the coastal flow ranges from 2 to 6 dyn cm. While salinity distributions show late summer low-salinity water on the shelf, baroclinic *coastal flow* in this area is two-three times weaker than the coastal flow to the west along the Kenai Peninsula. Differences between the two areas in magnitude and distribution of fresh-water input may explain the weaker coastal flow near Yakutat.

SEA LEVEL VARIATIONS IN RELATION TO COASTAL FLOW AROUND THE GULF OF ALASKA

J.D. Schumacher
R.K. Reed (both at NOAA, Pacific Marine Environmental Laboratory, Seattle, WA 98105)

We present adjusted mean monthly sea level deviations from six tide stations around the Gulf of Alaska (Sitka, Yakutat, Seward, Seldovia, Kodiak and Dutch Harbor) and then examine the deviations in light of our recent knowledge of shelf circulation. All stations had a similar general trend with maximum deviations in spring. Proceeding counterclockwise around the Gulf, however, there were systematic regional differences: the maximum became earlier in time from Sitka to Seldovia and was significantly smaller at Kodiak and Dutch Harbor. The differences in phase and amplitude appeared related to local coastal currents. On the east side of the Gulf, winter barotropic flows are dominant but the fall maximum along the Kenai Peninsula resulted from the seasonal variation in the baroclinic coastal flow. Further west, the sea level deviations were much smaller in the absence of distinct coastal flows.

RELATIONSHIP BETWEEN ANOMALIES OF SURFACE HEAT TRANSFER AND SEA SURFACE TEMPERATURE IN THE NORTHWEST GULF OF ALASKA.

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H. J. Niebauer
T. C. Royer (both at: IMS, U of AK, Fairbanks, AK 99701)

The results of heat balance computations of the upper 100 m on the northwest Gulf of Alaska shelf are used to investigate the relationship between monthly anomalies of surface heat transfer and sea surface temperature (SST). Oceanographic and meteorologic data collected from 1970 to 1978 are used to compute monthly balances for a composite year. During those months with a net heat gain, radiation is the major heat source. For those months with a net heat loss, latent and sensible heat flux dominate. Monthly anomalies of SST and change in SST are not linearly correlated with anomalies of cloud cover or latent plus sensible heat exchange. SST anomalies in the Gulf might be more closely related to vertical stratification and horizontal mixing and/or non-local effects such as secular variations in transport of the Alaskan Gyre or advection of SST anomalies from elsewhere in the North Pacific Ocean. Thus atmospheric influences on SST might be primarily indirect by the control of vertical stratification and mixing through wind stress, fresh water influx and wind stress curl.

SEASONAL VARIABILITY ON THE SOUTHERN VANCOUVER ISLAND CONTINENTAL SHELF.

K. Denman
H.J. Freeland (both at Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C. V8I 4B2, Canada.)

In 1979 and 1980 a water mass of high density and extremely low dissolved oxygen concentration inundated the continental shelf off southern Vancouver Island. Analysis of historical data from 1935 to 1975 suggests that this event occurs most years, but not all.

The results of several CTD surveys carried out this year will be presented. Evidence will be shown that the low oxygen water originates from the California Undercurrent and is steered onto the shelf by the Juan de Fuca Canyon and then by a spur canyon along 125°15'W. The northern end of the spur canyon is shown to be an important source of upwelled nutrients on the southern shelf.

The relationship of the flow patterns deduced from density, oxygen and nutrient mapping to the flows as seen by current meter moorings will also be discussed.

CURRENTS ALONG THE WEST COAST OF VANCOUVER ISLAND

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R.E. Thomson
W.S. Huggett (all at: Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C. V8L 4B2)

Sea level gauges and current meter arrays have been moored on the continental shelf and slope of Vancouver Island since May 1979. During the summer of 1979, two meteorological buoys were placed in one of these arrays, located off Estevan Point. There are five separate moorings in this array beginning 15 km from Estevan Pt., and ending 100 km from shore at the outer edge of the continental slope.

The low passed (half power at 40 hr) alongshore currents, measured at the two moorings on the shelf, are coherent with the local alongshore wind component and with adjusted sea levels at shore. The average current at 20 m depth from mid-May to mid-August is southeastward at 10 cm/sec, and decreases in magnitude with depth. The fluctuating components decrease in magnitude from peaks of 40 cm/sec near shore to 15 cm/sec on the mid-slope and 10 cm/sec at the outer slope.

Adjusted sea levels are similar along the entire island, but currents measured beyond the shelf break correlate poorly with those sea levels. However, alongshore currents on the continental slope are found to be coherent over distances of 150 km alongshore.

SHELF-FJORD EXCHANGE ON THE WEST COAST OF VANCOUVER ISLAND

D.J. Stucchi (Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.)
W.H. Bell, (Institute of Ocean Sciences, Patricia Bay, Sidney, B.C.)

Recent current meter observations obtained near the outer sill of Alberni Inlet provide more startling evidence of the strength and persistence of the exchange between the fjord and the adjacent continental shelf. The exchange appears to be controlled by the offshore wind field as there is good correlation between upwelling indices and the direction of the exchange. The exchange is strongest in the late fall and winter months when it is confined to the water column above sill depth (100m). Major periods of deep water renewal occur during late spring and early summer, coincident with the increasing density of the adjacent shelf waters.

ON THE FLUSHING OF PORT VALDEZ, ALASKA

J.M. Colonell (Woodward-Clyde Consultants, 4791 Business Park Blvd., Anchorage, AK 99503)

Currents were measured in Valdez Narrows for more than two years to examine the exchange of water between Port Valdez and Prince William Sound. To obtain information on the net exchange of water through the Narrows, the tidal signal was removed from the current meter data with a Butterworth low-pass filter.

Attention is focused on significant events with durations of two to five days, which appear as surges of surface water into Port Valdez that are accompanied by large outflows from depths greater than 50 to 65 m. These events seem to be related to the passage of weather systems through south-central Alaska and are probably much more effective in promoting deep water exchange than either tidal action or annual bottom water intrusions. Estimates of the outflows for selected events have magnitudes exceeding 15 to 20% of the volume of Port Valdez, indicating that only a few such events would be required to flush the fjord [illegible].

The random nature of the apparently weather-related events, in conjunction with the more predictable seasonal and tidal exchange processes, implies that the notion of a unique residence time for Port Valdez is inappropriate. However, the observational evidence suggests that a conservative estimate of a composite residence time is probably no more than a few weeks. These conclusions should apply to other fjords of southcentral Alaska, and perhaps to some in southeastern Alaska and northern British Columbia, since most are subject to the same meteorologic and oceanographic forcing functions.

*Formerly, Institute of Marine Science, University of Alaska, Fairbanks.

POLLUTANT MOVEMENT IN A SHALLOW ARCTIC FIORD

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Lead and cadmium from mine tailings deposited in a small Greenland fiord have been found in surface waters and distributed nearby in a larger fiord system.

CTD soundings taken over several years indicate complete vertical mixing in most winter seasons even though stable conditions exist in summer. Analysis of a year long current meter record made it possible to infer three mechanisms for vertical movement in winter. These are: salt driven convection near the growing ice sheet; deep convection from salt enriched shallows; turbulence generated by a tidally resonant internal seiche. In addition an influx of dense water coincident with the onset of spring run-off was recorded.

The vertical movement of basin waters resulting from these processes makes small Arctic fiords unattractive for the disposal of pollutants.

WAVE RUNUP ON OREGON BEACHES

R.A. Holman (School of Oceanography, Oregon State University, Corvallis, OR, 97331)

The Oregon coast provides an ideal environment for a field investigation of infragravity waves (wave periods 30-300 seconds) on beaches. Varying grain sizes give rise to a variety of beach slopes, headlands cut the straight beaches into cells with length scales from hundreds to tens of thousands of meters, and incident wave conditions vary from low to extremely energetic.

Infragravity waves have been linked to offshore beach profile perturbations such as sand bars, and may provide an important erosional force on the beach face. Field studies of infragravity waves on Oregon beaches have been carried out using time-lapse photography of wave runup. Analyses of initial runs have shown the dominance of several, well-defined spectral peaks at periods of the order of 100 seconds. This is in marked contrast to east coast observations which show smooth infragravity spectra. In fact, these contrasting observations are predicted by theoretical considerations of edge wave generation. This west coast runup spectra are expected to show a few peaks, each representing a low-mode edge wave.

NON-EFFECTS OF WAVE-INDUCED MOORING NOISE ON TIDAL AND LOW-FREQUENCY CURRENT OBSERVATIONS

C.A. Pearson
J.D. Schumacher (both at: NOAA, Pacific Marine Environmental Laboratory, Seattle, WA 98105)
R.D. Muench (SAI, Bellevue, WA 98005

Because of the controversy over the effects of surface wave motion on current meters, we have compared summer and winter M_2 tidal current speeds measured by Aanderaa current meters on subsurface moorings from several locations on the Gulf of Alaska continental shelf. Seasonal differences were slight and in most cases not significantly correlated with mean wave height measured at Buoy EB-3. We conclude that seasonally averaged low frequency currents measured by Aanderaa current meters on moorings with the float at least 18 meters below the surface are not seriously contaminated by surface-wave induced mooring motion.

Aeronomy

0410 Absorption and Scattering of Radiation
DETERMINATION OF ARTIFICIAL AURORAL STREAK WIDTHS USING GUIDING CENTER DIFFUSION THEORY
C. L. Lin and D. J. Strickland (Beers Associates, Inc., P. O. Box 2549, Reston, Virginia 22090)

The theory of two-dimensional random walk is applied to the problem of guiding center diffusion of kilovolt electrons caused by particle-particle interactions. The mean radius of the guiding center distribution is shown to depend, in a simple way, on the scattering and energy loss properties of the interactions. A formula for the width of an artificial auroral streak is derived which is consistent with observations and Monte Carlo results.
J. Geophys. Res., Blue, Paper 1A0184

0430 Composition (atomic or molecular)
A ZONALLY-AVERAGED CHEMICAL-DYNAMICAL MODEL OF THE LOWER THERMOSPHERE
J.F. Kasting and R.G. Roble (National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO, 80307)

A zonally averaged numerical model of the thermosphere is used to examine the coupling between neutral composition, including N_2, O_2, and O, temperature, and winds at solstice for solar minimum conditions. The meridional circulation forced by solar heating results in a summer-to-winter flow, with a winter enhancement in atomic oxygen density that is a factor of about 1.8 greater than the summer hemisphere at 160 km. The O_2 and N_2 densities are found to be higher in the summer hemisphere by factors of 2 to 3 at altitudes near 100 km. The O_2 and N_2 variations are associated with a latitudinal gradient in total number density, which is required to achieve pressure balance in the presence of large zonal jets. Latitudinal profiles of OI (5577 Å) green line emission intensity are calculated using both Chapman and Barth mechanisms. Composition of the lower thermosphere is shown to be strongly influenced by circulation patterns initiated in the stratosphere and lower mesosphere, below the lower boundary used in the model. (Thermosphere, Composition, Winds).
J. Geophys. Res., Green, Paper 1C0169

0440 Convection, diffusion, mixing turbulence, and fallout
VERTICAL TRANSPORT AND PHOTOCHEMISTRY IN THE TERRESTRIAL MESOSPHERE AND LOWER THERMOSPHERE (50-120 KM)
M. Allen, (Calif. Institute of Technology, 170-25, Pasadena, CA 91125) Y.L. Yung and J.W. Waters

The coupled effects of kinetics, solar cycle flux variations and vertical transport on the distribution of long-lived hydrogen-carbon-oxygen compounds in the terrestrial mesosphere and lower thermosphere are studied using a one dimensional aeronomy model. The calculations account for the important chemical reactions and use rocket measurements of the solar flux at solar minimum and maximum. Photodissociation rates appropriate for the mesosphere are determined with a spherical shell atmosphere formalism; detailed corrections for the O_2 Schumann-Runge bands and the temperature dependence of the CO_2 cross-sections are used. Then an eddy diffusion profile is derived which gives agreement with the Aladdin 74 mass spectral measurements of atomic O, O_2, CO_2, and Ar in the lower thermosphere and observations of the O_2 minimum at ~80 km. The 115 GHz CO radio emission line computed for the CO mixing ratio profile predicted with the new eddy diffusion profile compares well with recent observations of W.J. Wilson. Differences between the calculated CO mixing ratio profile and previous theoretical and observational determinations are discussed. Our derived eddy diffusion profile has a sudden decrease at 92 km which is necessary to produce the atomic O peak at 98 km that appears in the Aladdin 74 measurements. This stagnant region apparently is a recurrent or persistent feature of the upper atmosphere since an atomic O peak around 98 km has been seen by different techniques in different seasons over several years. Slow eddy diffusion in the lower thermosphere through the homopause was also the conclusion of earlier Ar/N_2 rocket measurement studies. The analytic approach of this paper could be used in the future to monitor variations in middle atmosphere dynamics, if regularly-conducted simultaneous observations of various groups of species were available.
J. Geophys. Res., Blue, Paper 80A1817

0450 Pressure, density, and temperature
SEMI-EMPIRICAL MODELLING OF THERMOSPHERIC MAGNETIC STORMS
A. E. Hedin (NASA/Goddard Space Flight Center, Greenbelt, MD 20771), N. W. Spencer, H. G. Mayr, and H. S. Porter

An improved formulation for empirical modelling of magnetic storm effects in neutral thermospheric composition and temperature is utilized in a study of two disturbed periods. The formulation, which incorporates the prior history of the heat input rather than a single phase delay, is based on a Fourier integral representation of an existing theoretical model. This results in an improved representation of the detailed time variations, a better carryover of model parameters from one storm to the other, and provides a basis for theoretical interpretation. (Modelling, Temperature, Composition, Magnetic Storms).
J. Geophys. Res., Blue, Paper 1A0157.

0460 Tides, waves, and winds
INFRASONIC OSCILLATIONS IN THE F2 - REGION ASSOCIATED WITH SEVERE THUNDERSTORMS
D.G. Krishnan Raju (Space Research Laboratories, Department of Physics, Andhra University, Waltair, India) M. Srirama Rao, B. Madhusudana Rao, C. Jogulu, C. Poornachandra Rao and R. Ramanadham

Phase path variations of F2 - region echoes on 5.6 MHz over Waltair (geogr. lat. 17° 43' N; long. 83° 18' E) are found to exhibit prominent short period reversals on some occasions during summer evening hours. The observed waves have periods in the range of 0.5 to about 5 min. The spectral content of the ionospheric waves is found to vary from one storm event to another. These disturbances are apparently associated with severe local thunderstorms in the troposphere and are interpreted as ionospheric manifestations of acoustic waves generated in the storm sources. The mechanical oscillations excited during the culminating growth of a thundercloud are likely the source of the observed ionospheric disturbances. A simple model for the generation of acoustic waves by developing thunderstorms is suggested. (Infrasound, thunderstorms, F2 - region, energy estimates).
J. Geophys. Res., Blue, Paper 1A0078

Electromagnetics

0773 Remote Sensing
DISCRIMINATION OF A CHESTNUT-OAK FOREST UNIT FOR GEOLOGIC MAPPING BY MEANS OF A PRINCIPAL COMPONENT ENHANCEMENT OF LANDSAT MULTISPECTRAL SCANNER DATA
M. Dennis Krohn (U.S. Geological Survey, Mail Stop 927, Reston, Virginia 22092) N. M. Milton, Donald Segal and Anthony England

A principal component image enhancement was applied to a winter Landsat scene to assist geologic mapping in the heavily forested Coastal Plain and Piedmont of eastern Virginia. The image enhancement procedure consists of a principal component transformation, a histogram normalization, and the inverse principal component transformation. Slope and intercept values for the linear histogram normalization are derived to keep the scale constant between the raw Landsat data and the inverted principal component data. The enhancement preserves the independence of the principal components, yet produces a more readily interpretable image than does a single principal component transformation.

A chestnut-oak (Quercus prinus) forest unit, which occurs on metavolcanic rocks and some metaclastic rocks in the western Piedmont and on highly weathered upland gravel deposits in the eastern Piedmont, can be discerned on the inverted principal component image. In the inverted principal component data, the chestnut-oak forest unit is characterized by a larger value for the band 5 equivalent than for the band 4 equivalent. However, in the raw Landsat bands, band 4 is larger than band 5 for all four forest units examined. Such observations cannot be readily deduced from analysis of only the principal component rotation matrix, and they may ultimately provide a means to map the distribution of chestnut-oak forest from Landsat. (Image processing, geobotany, principal-components).
Geophys. Res. Lett., Paper 1L0068